

## ACID DEPOSITION IN UTAH

A PROGRESS REPORT OF THE ACTIVITIES  
OF THE UTAH ACID DEPOSITION  
TECHNICAL ADVISORY COMMITTEE DURING 1987

Sponsored by: The Utah Acid Deposition Technical Advisory Committee (ADTAC)  
The Utah State Department of Health

April 1990

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Utah State Department of Health





# State of Utah

## DEPARTMENT OF HEALTH

### DIVISION OF ENVIRONMENTAL HEALTH

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## EXECUTIVE SUMMARY

The Acid Deposition Technical Advisory Committee (ADTAC), was created in 1986 at the request of Governor Norman H. Bangerter to determine the status of acid deposition in Utah. The focus of the Committee, in addition to keeping abreast of acid deposition research, issues, and policy decisions, has been to define areas in Utah which may be sensitive to acid deposition and to collect baseline data in order to establish trends which may result from acid deposition.

In defining areas of Utah sensitive to acid deposition, a classification of Utah's bedrock as to its acid neutralization capacity (ANC) was done. Also, a Western Lakes Survey (WLS) was conducted and the water chemistry data was used to determine the ANC of the lakes and streams sampled.

Based on bedrock ANC, the largest area found to be sensitive to acid deposition was the Uinta Mountains. Also, the ANC of the sampled lakes and streams in the Uinta Mountains was consistently low. While the Uinta lakes did not have the lowest range of ANC in the WLS, the standard deviation was so small and the mean was so low, that as a group, these lakes must be considered to be extremely sensitive. The consistent nature of low ANC values would make the Uinta lakes an ideal area for further regional studies. The WLS also verified ADTAC's contention that the Boulder Mountain lakes are also sensitive to acid deposition.

There has been a lot of work, time, and dedication put into this report. I would like to express my sincerest appreciation to all those who have participated and been involved in this project.

Sincerely,

*F. Burnell Cordner*  
F. Burnell Cordner, Executive Secretary  
Utah Air Conservation Committee



## CONTENTS

I. ACROYNM LEGEND .....	Pg. 1
II. INTRODUCTION .....	Pg. 2
III. ACKNOWLEDGEMENTS .....	Pg. 3
ADTAC Members - 1987 .....	Pg. 4
ADTAC Report Contributors .....	Pg. 4
IV. ADTAC ACTIVITIES DURING 1987, SUMMARY AND RECOMMENDATIONS .....	Pg. 5-6
ADTAC Recommendations for 1988 .....	Pg. 7
Acid Deposition Action Plan .....	Pg. 8-13
V. REPORTS AND PROJECT SUMMARIES .....	Pg. 14
Bedrock Acid Neutralization Capacity and its Role in Predicting Sensitive Watersheds in Utah. Loren Morton, Geologist - Utah Bureau of Water Pollution Control .....	Pg. 15-30
Utah 1987 High Elevation Stream and Lake Sampling Program. Richard Denton, Harry Judd, Bureau of Water Pollution Control. Maureen Wilson - Division of Wildlife Resources .....	Pg. 31-60
Snow Core Sampling Program, Winter 1987-1988. Joint Effort-Soil Conservation Service, Utah Bureau of Air Quality, and Utah State Health lab .....	Pg. 61-64
VI. APPENDIX .....	Pg. 65
ADTAC Meeting, January 9, 1987 Results of Assignments .....	Pg. 66-67
ADTAC Meeting, April 23, 1987 .....	Pg. 68-69
Acid Deposition in Utah. Logan Jubeck Field Notes: Pittsburg Lake .....	Pg. 70-71
Acid Deposition in Utah. Lamont Jubeck Field Notes: Lake Hardy .....	Pg. 72-73
Eagle Project Report. Reid H. Ellis September 30, 1987 .....	Pg. 74-75



## I. ACRONYM LEGEND

ADTA	-	Acid Deposition Technical Advisory Committee
ANC	-	Acid Neutralizing Capacity
AQRV	-	Air Quality Related Values
BAQ	-	Bureau of Air Quality
BLM	-	Bureau of Land Management
BWPC	-	Bureau of Water Pollution Control
DWR	-	Division of Wildlife Resources
EPA	-	Environmental Protection Agency
FLM	-	Federal Land Managers
MDL	-	Minimal detection limit
SCS	-	Soil Conservation Service
SLF	-	State Lands and Forestry
TDS	-	Total Dissolved Solids
TOC	-	Total Organic Carbon
TSS	-	Total Suspended Solids
QA	-	Quality Assurance
UACC	-	Utah Air Conservation Committee
UP&L	-	Utah Power and Light
USFS	-	United States Forest Service
USGS	-	United States Geological Survey
USU	-	Utah State University
UWPC	-	Utah Water Pollution Control Committee
WPC	-	Water Pollution Control
WRL	-	Water Research Laboratory
WLS	-	Western Lake Survey





## II. INTRODUCTION

Since the Acid Deposition Technical Advisory Committee's (ADTAC) inception in 1986, its members have spent many hours collecting, compiling, and disseminating information on acid deposition in Utah and in the West. Two of the most startling realizations uncovered by this committee were that: 1) in addition to the Uinta Mountains, there may be other areas in Utah which can be labeled "sensitive" to acid deposition, and 2) very little baseline data of any kind exist for these potentially "sensitive" areas, by which it could be determined whether they have been subjected to and/or affected by acid deposition.

The focus of ADTAC, in addition to keeping abreast of acid deposition research, issues, and policy decisions, has been to promote efforts to further define the areas in Utah which may be sensitive to acid deposition and to encourage the collection of baseline data necessary to establish trends which may result from acid deposition.

The following report outlines the activities of ADTAC during 1987, and presents the research and projects which have been undertaken as a result of ADTAC's recommendations and the commitment of private industry, private individuals, and state and local government agencies to determine the status of acid deposition in Utah.



### III. ACKNOWLEDGMENTS

The Acid Deposition Technical Advisory Committee (ADTAC), formed at the request of Governor Norman H. Bangerter, was created to determine the status of acid deposition in Utah; to determine what information would be needed to complete the scientific understanding of acid deposition in Utah; and to provide technical recommendations to the Utah Air Conservation Committee and the Utah Water Pollution Control Committee on policy decisions concerning acid deposition. In accomplishing these objectives ADTAC has contributed greatly to the understanding of the problems, both real and potential, which acid deposition poses to Utah.

The reports and projects presented here have been made possible by Governor H. Bangerter, who requested the formation of a technical advisory task force to study acid deposition in Utah; by the direction and support of ADTAC; by the dedication and commitment of the staff members of many agencies, both public and private; and by the concern of the citizens of Utah about acid deposition. The time and dedication of all members who served on ADTAC is gratefully appreciated.

A great deal of credit must go to Mark Ellis, the former coordinator and chairman of ADTAC, for the success of this group. His enthusiasm, and organizational skills enabled ADTAC to make steady progress towards fulfilling its objectives. In addition to Mark Ellis's contribution to this study, acknowledgements go to Carol Revelt of the Bureau of Air Quality. Carol took over as chairman of ADTAC upon Mark's resignation from the Bureau of Air Quality. Ms. Revelt's efforts have lead to the finalization of this progress report. Both Mark and Carol have since left the state government to pursue careers in the private business sector. Their leadership and hard work are appreciated.

North 21° 30' W. 1000 yds. 1200 yds. 1300 yds.

2000 yds. 2100 yds. 2200 yds.

1000 yds.

1000 yds. 1100 yds. 1200 yds.

1300 yds. 1400 yds. 1500 yds.

**THE MEMBERS OF THE ACID DEPOSITION TECHNICAL ADVISORY COMMITTEE DURING 1987  
ARE COMMENDED FOR THEIR SUPPORT:**

Dr. Dee Barker, Utah Air Conservation Committee  
Clif Benoit, U.S. Forest Service  
Rolf Doebling, Utah Bureau of Air Quality  
Dr. Lynn Dudley, Department of Soil Science and Biometry, Utah State University  
Mark Ellis, Utah Bureau of Air Quality  
Dr. Mary Fleming, Wasatch Mountain Club  
Emily Hall, Utah Air Conservation Committee  
Ray Hall, U.S. Forest Service  
Dr. Clyde Hill, University of Utah Research Institute  
Eugene J. Marshall, Utah Power and Light  
Jay Pitkin, Utah Bureau of Water Pollution Control  
David Schen, Utah State Lands and Forestry  
Dr. Doyle Stephens, U.S. Geologic Survey  
Larry Svoboda, EPA Region VIII  
Dr. William Wagner, U.S. Bureau of Land Management  
Dr. Fred Wagner, College of Natural Resources, Utah State University  
Maureen Wilson, Utah Division of Wildlife Resources  
Dr. Wayne Wurtsbaugh, College of Natural Resources, Utah State University

**CONTRIBUTORS TO THE 1987 ADTAC REPORT INCLUDE:**

William Case, Utah Geological and Mineral Survey  
Richard Denton, Utah Bureau of Water Pollution Control  
Mark Ellis, formerly of the Utah Bureau of Solid and Hazardous Wastes & Utah Bureau of Air Quality  
Reid Ellis, volunteer Boy Scout  
Lynn Hutchinson, Manager of Kennecott's Environmental Laboratory  
Lamont Jubeck, volunteer Boy Scout  
Logan Jubeck, volunteer Boy Scout  
Harry Judd, Utah Bureau of Water Pollution Control  
Loren Morton, Utah Bureau of Water Pollution Control  
Mike Reichert, Utah Bureau of Water Pollution Control  
Carol Revelt, formerly of Utah Bureau of Air Quality  
Maureen Wilson, formerly of Utah Division of Natural Resources  
Ray Wilson, U.S. Soil Conservation Survey--Snow Surveys  
Carol Keller, Bureau of Air Quality





#### IV. ADTAC ACTIVITIES DURING 1987: SUMMARY AND RECOMMENDATIONS

In 1986 ADTAC recommended the following:

1. The State of Utah should become involved in the scientific study of acid deposition.
2. Monitoring must be done in sensitive and potentially sensitive areas in Utah.
3. Air pollution sources within the State should be monitored for their impact on Utah's acid contribution.
4. ADTAC or a similar technical committee should be continued in order to provide technical updates to the States policy makers

During 1987 ADTAC held meetings on January 9 and on May 23 (see the Appendix for meeting summaries) to continue the work begun in 1986 and to discuss ways to achieve the recommendations set forth during 1986. The result of these meetings and the efforts of Mark Ellis was development of the "Acid Deposition Action Plan". The plan, contained on the following pages, outlines a strategy for accomplishing the objectives set forth in 1986.

As a result of this plan the following projects were completed during 1987:

1. Staff members of the Bureau of Water Pollution Control, the Bureau of Land Management, the Division of Wildlife Resources, the Bureau of Air Quality, and three volunteer Boy Scouts, collected lake and stream samples in 10 suspected sensitive areas in Utah. These samples were analyzed by Kennecott's Environmental Laboratory under the direction of Lynn Hutchinson. Maureen Wilson, formerly of the Division of Wildlife Resources, compiled fishery data available for the lakes and streams which were sampled. Finally, members of the Bureau of Water Pollution Control, Division of Wildlife Resources, and the Bureau of Air Quality compiled and summarized these water quality data.
2. Loren Morton of the Bureau of Water Pollution Control, while adapting Norton's work on bedrock acid neutralizing capacity to Utah, wrote a paper which discusses the basis of a system and will predict acid neutralizing capacities of various rock types; and classifies may of Utah's watersheds according to their bedrock Acid Neutralizing Capacities (ANC).
3. Bill Case of the Utah Geological and Mineral Survey, in conjunction with Loren Morton's work and Norton's preliminary bedrock ANC map, created an overlay for the 1:500,000 Geologic Map of Utah, based on the acid neutralizing capacities of the bedrock geology of the State. This overlay will be available from the Utah Geological Mineral Survey as an Open File report.

4. Snow core sampling protocol was developed for sampling six sites in Utah, following the techniques used by the U.S. Forest Service in the Bridger-Teton Wilderness area. The snow core sampling program, supported by the U.S. Soil Conservation Survey - Snow Survey Program, began collecting samples in December, 1987 and continued into 1989.
5. An Air Quality Related Values Study of the High Uinta Mountains was developed by staff members of the Ashley National Forest. A visibility camera is in place at Lake Fork Mountain, and the U.S. Forest Service is attempting to negotiate the installation of other air monitoring devices near that location.
6. Members of the Bureau of Air Quality have continued to update the Acid Deposition Library and the State's emissions inventory, and to keep abreast of recent developments in acid deposition research and legislation.

In addition to ADTAC's work, staff members of the National Park Service have drafted a proposal to study the sensitivity of cryptogamic crusts and ephemeral rock pool in the Colorado Plateau area to wet and dry air pollutants.

One of the areas in which ADTAC's efforts were not very successful was the failure to establish any high elevation acid deposition monitoring sites, which are necessary to assess acid loading rates. EPA and staff of the Ashley National Forest have discussed the possibility of locating a National Dry Deposition Monitoring Network station at Lake Fork, on the South Flank of the Uinta Mountains. The data from this site would provide valuable information for the study of acid deposition in the largest sensitive area in Utah. The need for dry deposition monitors cannot be understated because in the arid west we have no feel for that portion of acid deposition which results from dry deposition.

All-in-all, 1987 was an important year for beginning data collection and for further understanding the sensitivity of Utah to acid deposition.



### **ADTAC RECOMMENDATIONS FOR 1988:**

1. The lake and stream sampling program should be continued in areas designated "sensitive" by the 1987 water chemistry data.
2. Efforts should be continued to establish acid deposition sampling monitors at high elevations in sensitive areas.
3. ADTAC should continue to meet on a regular basis to keep up-to-date on acid deposition research and issues.
4. Interagency projects should be encouraged as much as possible in order to avoid duplication of efforts and to draw upon as many resources as possible.





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BAQ-4343-2

Revised Draft

**MEMORANDUM TO:** F. Burnell Cordner, Director  
**THROUGH:** Montie R. Keller, Environmental Health Manager  
**FROM:** Mark T. Ellis, Environmental Health Scientist  
**DATE:** May 7, 1987  
**SUBJECT:** Acid Deposition Action Plan

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### Introduction

In response to the directive of the Air Conservation Committee, Water Pollution Control Committee, and the Wildlife Board to develop a monitoring plan consistent with the recommendations made by the Acid Deposition Technical Advisory Committee (ADTAC), the following plan has been developed. The agencies responsible for certain defined tasks, are listed with the assignments to which they have preliminarily agreed. The finalization of the assignments will come after the action plan is approved by each participating agency or industry and the responsible agent from each agency signs off on the plan.

### Objectives

1. Define areas in Utah which are sensitive to acid deposition. The definition of sensitivity adopted by ADTAC is the definition used by EPA, i.e. surface water alkalinity values less than 200 ueq/l. Other criteria of sensitivity which consider soil sensitivity, proximity to heavy acid loading sources or other values, may later be used when additional definitions for sensitivity criteria are developed.
2. Areas defined as sensitive will be studied to establish the following:
  - a. the degree of sensitivity;
  - \* b. the loading rate of atmospheric acids;
  - \* c. the resources at risk if the buffering capacity of a sensitive watershed is lost or diminished;
  - \* d. the threshold limit or annual tolerance of atmospheric acids into a sensitive watershed; and
  - \* e. the watershed indicators which may be used to signal changes in the ecology, attributable to atmospheric deposition
3. The State will work with the statutory committees and industry to advocate those acid deposition bills which will do the most good for Utah.

The monitoring plan for 1987 is designed to address objectives 1 and 2a. The accomplishment of the objectives 2b through 2e (\*) is dependant upon specific funding from the State Legislature, Congress, or other sources. The 1987 monitoring plan will enable the State to establish a basic sampling routine and begin the establishment of a database. By January 1988, results of the 1987 sampling year will be reported

to the three statutory committees presently involved with the issues surrounding acid deposition, i.e., Air Conservation Committee, Water Pollution Control Committee, and Wildlife Board.

The Federal Land Manager (FLM) may become involved in doing much of the work presently being proposed by the State in the monitoring portion of the action plan. Cooperation with the FLM through ADTAC will be sought to ensure that the State remains a part of monitoring efforts conducted within the State. For the monitoring that the State wishes to conduct, cooperation with the FLM will also be give through data sharing.

Objective 3 addresses non-technical, political issues dealing with acid deposition on a regional or national scale. Pending Congressional legislation could either be detrimental or beneficial to both industry and the environment, depending upon which of the many bills becomes law. In the past, the State has come out against federal legislation which mandates a national tax to provide midwestern and eastern polluters with capital for pollution control equipment. If the impact of a national tax is of concern to Utah, perhaps it is appropriate for the State to play the role of an advocate for specific legislation which favors Utah's interests. Political advocacy on the acid deposition issue may involve the State, concerned Utah industries, and the statutory committees (Air Conservation Committee, Water Pollution Control Committee, and Wildlife Board). ADTAC should not be permitted to be involved in the political issues since it was designed to serve as a technical advisor to the State and the statutory committees. Objective 3 is appropriately addressed by the non-technical bodies. Several industries including Utah Power and Light Company, Kennecott, and Nucor Steel have been contacted concerning the ramifications of pending Congressional acid deposition bills. They have expressed the desire to present a unified voice on the issue of federal legislation, providing that larger corporate interests do not interfere with the opinions of the local industry on the matter.

#### Tasks

The following tasks have been negotiated with the following agencies for completion in 1987:

##### **Bureau of Air Quality (BAQ) -**

1. Serve as a clearinghouse for state and federal agencies involved in this State plan or any other acid deposition monitoring plan in Utah;
2. coordinate between agencies to ensure coverage of sensitive area monitoring assignments as agreed to in this plan;
3. provide source emissions data for ADTAC as required; and
4. report the final results obtained by the respective agencies to the Air Conservation Committee, Water Pollution Control Committee, and Wildlife Board.

##### **Bureau of Water Pollution Control (BWPC) -**

1. Collect two surface water samples from at least two sites in the spring and late summer at the following locations: Raft River, Pine Valley, Thousand Lake, and Boulder Mountains;
2. receive and interpret surface water quality data collected by BWPC and other agencies participating in this plan; BWPC will serve as the lead agency on water sampling;
3. complete spring and late summer surface water sample analyses for submittal to ADTAC by November 1, 1987; and
4. ensure analysis of water samples by the assigned laboratory.



**Division of Wildlife Resources (DWR) -**

1. Conduct fisheries surveys for Shadow, Rhoads, and Allred Lakes, or compile a summary of existing data verifying the fisheries data on those lakes;
2. evaluate suitable waters for conducting fisheries work in the Boulder Mountains;
3. make recommendations for suitable monitoring sites in the Boulder Mountains based upon fisheries stability;
4. data completed for the 1987 monitoring year will be submitted to BAQ for inclusion to the annual report; and
5. DWR will serve as the lead agency for aquatic and wildlife data collected by any agency.

**State Lands and Forestry -**

1. Collect two surface water samples for analysis (through BWPC) from two sites in the La Sal and Tushar Mountains; one sample will be taken in the spring, another in late summer.

**Bureau of Land Management (BLM) -**

1. Collect two surface water samples for analysis (through BWPC) from two sites in the Deep Creek and Henry Mountains; one sample will be taken in the spring, another in late summer.

**U.S. Forest Service -**

1. Coordinate AQRV study proposed for the Wasatch and Uinta Mountains with ADTAC, making relevant data available for inclusion into the State monitoring plan.
2. The U.S. Forest Service will serve as the lead agency for collecting and analyzing data relevant to the terrestrial ecosystem.

**Utah Geological and Mineral Survey -**

1. A map of Utah will be made to show the bedrock geology of the State, which may be composed of sensitive material. The map will be a 1 inch = 500,000 feet scale; the map will be completed by September 30, 1987.

**U.S. Geological Survey -**

1. Field alkalinity measurements will be made of watersheds designated for surface water monitoring. Field measurements will be taken at the gaging stations located uppermost in the monitored watersheds. Field data will be analyzed and turned into the BAQ by November 1, 1987 for inclusion into the annual report.
2. A soil analysis method will be recommended to typify the acid neutralizing capacity of soils located in the sensitive areas being monitored.

**Soil Conservation Service -**

1. Snow core sampling will be retrieved for chemical analysis (through BWPC) from two sites in the Uinta and Boulder Mountains, to be coordinated with the U.S. Forest Service. Samples will be collected at each of those sites during each snow core survey for 1988.

## Utah Power and Light Company -

1. The Mirror Lake deposition monitoring site will be resumed by mid-summer 1987. Atmospheric deposition samples will be collected of wet and dry constituents. Sampling results for the 1987 collection year will not be reported until the annual report for 1988 is reported. UP&L will provide a summary of the previous three years deposition data for inclusion into the 1987 report.

## Kennecott

1. Sample analysis will be provided for surface water samples for 25 sites, two samples each; one in the spring and one in late summer. Results of the analyses will be reported to BWPC by October 31, 1987 for inclusion into the 1987 monitoring report.

Any agency, industry or private researcher who conducts acid deposition research, study or monitoring is not precluded from doing so by this or any other plan now implemented. The purpose of this plan is to consolidate the resources and objectives of the several groups which are concerned about, and responsible for acid deposition, its formation, control, and effects within the State of Utah. Any data relevant to this study will be welcomed in its proper context.

## Issues to be Resolved

1. Sampling locations in each of the sensitive/suspected sensitive areas have not yet been chosen. A list of proposed sites (attached) from which to choose was sent to each ADTAC member. Each of the sensitive areas to be monitored will have two sites where water and soil samples will be collected, as agreed. The exact sites for monitoring will be agreed upon by May 15, 1987.
2. The acid deposition action plan is unique among activities normally conducted by the State, certainly for the Department of Health. Since this plan is not a regulatory function, the action plan presents a different function for the Department. I believe that this function is fully justified under the statutory mandate found in the Utah Code, which created the air quality laws to protect human health, environment, and industry. However, the nontraditional function proposed in this plan will require a commitment from either the Department, Division, or the Bureaus for full time commitment by involved staff, as well as the allocation of a budget in the future for the accomplishment of recommendation #1 in the 1986 ADTAC report, which was upheld by the three statutory committees. That recommendation states:

"The State of Utah should become involved in the scientific study of acid deposition. Without legitimate scientific effort to justify proposed control measures, Utah sources could be placed in the position of complying with congressional directives without independent, first-hand knowledge of real needs."

3. Worthy of note are the private organizations which are also interested in participating with the State in monitoring acid deposition in Utah, and nationwide if possible. Jeff Orth, of Rocky Mountain Research, is attempting to build a continuous water sampling device that has the capability of automatically analyzing ambient waters, and then transmitting the results to a computer for instantaneous tabulation. Such a device would be the first in the world of its kind, since Mr. Orth is thinking of having the sampler analyze for constituents which have traditionally been analyzed by bench chemistry.

4. Negotiations will continue with the Water Research Laboratory (WRL) in Logan, to have that group perform the water quality analyses on the samples collected by this program. Analysis for the waters to be sampled in the sensitive areas is more difficult due to the dilute nature of these waters. To perform these analyses, WRL will be required to purchase new equipment, capable of analyzing dilute water samples. WRL is, therefore trying to adjust its exiting budget so that the necessary equipment can be purchased. Since the WRL is research oriented, the sensitive area water monitoring project would be ideal for WRL. When and if the WRL gains the funding and capacity to perform the dilute water chemistries, it might be in the best interest of the monitoring project to arrange for sample analysis by WRL instead of the State Health Lab or Kennecott.
5. Upon the advise of Dr. Lynn Dudley, soil sampling by crews picking up water samples will not be conducted. Dr. Dudley advised in the April 23, 1987 ADTAC meeting, that soil horizons should not be mixed and that ignorance of soil strata could lead to the collection of misrepresentative samples. Arrangements for existing data to be used by ADTAC will be made with U.S. Forest Service, U.S.U. and BLM. To fill the gaps in the needed soils data, special efforts to collect accurate samples for analysis will be made.





The 1987 acid deposition action plan as proposed by the Department of Health is agreeable to the following agencies, which will perform the tasks as agreed. The following are authorized to commit to performing the previously designated tasks for the year 1987.

\_\_\_\_\_, on this date \_\_\_\_\_ 1987  
F. Burnell Cordner, Director, Bureau of Air Quality

\_\_\_\_\_, on this date \_\_\_\_\_ 1987  
Calvin K. Sudweeks, Director, Bureau of Water Pollution Control

\_\_\_\_\_, on this date \_\_\_\_\_ 1987  
William Geer, Director, Division of Wildlife Resources

\_\_\_\_\_, on this date \_\_\_\_\_ 1987  
State Lands and Forestry

\_\_\_\_\_, on this date \_\_\_\_\_ 1987  
Jens Jensen, District Chief, Bureau of Land Management

\_\_\_\_\_, on this date \_\_\_\_\_ 1987  
Ray Hall, Watershed Chief, U.S. Forest Service

\_\_\_\_\_, on this date \_\_\_\_\_ 1987  
Genevieve Atwood, Director, Geological and Mineral Survey

\_\_\_\_\_, on this date \_\_\_\_\_ 1987  
Lee Case, District Chief, U.S. Geological Survey

\_\_\_\_\_, on this date \_\_\_\_\_ 1987  
Soil Conservation Service

\_\_\_\_\_, on this date \_\_\_\_\_ 1987  
Utah Power and Light Company

\_\_\_\_\_, on this date \_\_\_\_\_ 1987  
Kennecott



V. REPORTS AND PROJECT SUMMARIES



# **BEDROCK ACID NEUTRALIZATION CAPACITY AND ITS ROLE IN PREDICTING SENSITIVE WATERSHEDS IN UTAH**

By: Loren Morton, Geologist  
Utah Bureau of Water Pollution Control

## **Introduction**

Groundwater flow beneath the surface of the earth, and surface water runoff in streams, lakes, and rivers are two of the most fundamental paths in which the hydrologic cycle returns rainfall to the oceans. In both cases water is in intimate contact with soil and rock matter. Surface water not only flows across soil and rock, but also transports suspended soil and rock debris. Ground water migrates through open voids within soil or rock layers during its trip to the ocean. Both paths are interrelated, in that surface water may feed ground water aquifers, in turn, may replenish surface waters. Consequently, water is a flowing continuum.

In the case of acid precipitation, the low pH water can be buffered through their interplay with the soil and/or rocks during the hydrologic cycle. Because ground water has a longer contact or residence time with soil and rock than surface water, it has a greater opportunity to buffer low pH precipitation.

In the following pages I will discuss the concepts of water alkalinity and acid neutralization capacity (ANC) of soil and rock material. I will also present a modified bedrock ANC classification system and a simplified bedrock ANC map for the State of Utah. Finally, I will classify some of the major geologic features in Utah based on their acid neutralizing capacities.

## **Alkalinity**

As ground water passes through the soil and rock column it dissolves mineral matter. This dissolution process contributes to the total alkalinity of ground water and, in turn, of surface water.

Alkalinity of a water is a measure of its capacity to neutralize acids or  $H^+$  ion donors (Sawyer and McCarty, 1978). Total alkalinity of a water is the sum of all the anions in solution that will accept  $H^+$  ions. In most natural waters  $HCO_3^-$  and  $CO_3^{2-}$  constitute the majority of a water's total alkalinity (Drever, p. 40), and are consequently the most significant anions available for acid consumption. In neutral waters several anions provide alkalinity; however, most are found in very small concentrations compared to bicarbonate ( $HCO_3^-$ ) and carbonate ( $CO_3^{2-}$ ). Both  $HCO_3^-$  and  $CO_3^{2-}$  are derived from the atmosphere, whereby  $CO_2$  hydrolyzes to form small concentrations of carbonic acid,  $H_2CO_3$ , due to the partial pressure of atmospheric  $CO_2$  gas in water. As  $H_2CO_3$  charged water contacts rock and soil matter,  $H^+$  ions can be donated, thus generating  $HCO_3^-$  and  $CO_3^{2-}$  type ground and surface waters. If carbonate rocks or minerals are contacted in the process, extra  $HCO_3^-$  can be dissolved from the rock and added to the water, thus carbonate soils and rock are also a source of water alkalinity.

Table 1 Reactions for Incongruent Dissolution of Some Aluminosilicate Minerals\*

CLAYS	
<u>Na-montmorillonite - kaolinite</u>	
$\text{Na}_0.33\text{Al}_2.33\text{Si}_3.67\text{O}_{10}(\text{OH})_2 + 1/3\text{H}^+ + 23/6\text{H}_2\text{O} = 7/6\text{Al}_2\text{Si}_2\text{O}_5(\text{OH})_4 + 1/3\text{Na}^+ + 4/3\text{Si}(\text{OH})_4$	
<u>Ca-montmorillonite - kaolinite</u>	
$\text{Ca}_0.33\text{Al}_4.67\text{Si}_7.33\text{O}_{20}(\text{OH})_4 + 2/3\text{H}^+ + 23/2\text{H}_2\text{O} = 7/3\text{Al}_2\text{Si}_2\text{O}_5(\text{OH})_4 + 1/3\text{Ca}^{2+} + 8/3\text{Si}(\text{OH})_4$	
<u>Illite - kaolinite</u>	
$\text{K}_0.6\text{Mg}_0.25\text{Al}_2.30\text{Si}_3.5\text{O}_{10}(\text{OH})_2 + 11/10\text{H}^+ + 63/60\text{H}_2\text{O} = 23/20\text{Al}_2\text{Si}_2\text{O}_5(\text{OH})_4 + 3/5\text{K}^+ + 1/4\text{Mg}^{2+} + 6/5\text{Si}(\text{OH})_4$	
MICA	
<u>Biotite - kaolinite</u>	
$\text{KMg}_3\text{AlSi}_3\text{O}_{10}(\text{OH})_2 + 7\text{H}^+ + 1/2\text{H}_2\text{O} = 1/2\text{Al}_2\text{Si}_2\text{O}_5(\text{OH})_4 + \text{K}^+ + 3\text{Mg}^{2+} + 2\text{Si}(\text{OH})_4$	
FELDSPARS	
<u>Albite - kaolinite</u>	
$\text{NaAlSi}_3\text{O}_8 + \text{H}^+ + 9/2\text{H}_2\text{O} = 1/2\text{Al}_2\text{Si}_2\text{O}_5(\text{OH})_4 + \text{Na}^+ + 2\text{Si}(\text{OH})_4$	
<u>Albite - Na-montmorillonite</u>	
$\text{NaAlSi}_3\text{O}_8 + 6/7\text{H}^+ + 20/7\text{H}_2\text{O} = 3/7\text{Na}_0.33\text{Al}_2.33\text{Si}_3.67\text{O}_{10}(\text{OH})_2 + 6/7\text{Na}^+ + 10/7\text{Si}(\text{OH})_4$	
<u>Microcline - kaolinite</u>	
$\text{KAlSi}_3\text{O}_8 + \text{H}^+ + 9/2\text{H}_2\text{O} = 1/2\text{Al}_2\text{Si}_2\text{O}_5(\text{OH})_4 + \text{K}^+ + 2\text{Si}(\text{OH})_4$	
<u>Anorthite - kaolinite</u>	
$\text{CaAl}_2\text{Si}_2\text{O}_8 + 2\text{H}^+ + \text{H}_2\text{O} = \text{Al}_2\text{Si}_2\text{O}_5(\text{OH})_4 + \text{Ca}^{2+}$	
<u>Andesine - kaolinite</u>	
$\text{Na}_0.5\text{Ca}_0.5\text{Al}_1.5\text{Si}_2.5\text{O}_8 + 3/2\text{H}^+ + 11/4\text{H}_2\text{O} = 3/4\text{Al}_2\text{Si}_2\text{O}_5(\text{OH})_4 + 1/2\text{Na}^+ + 1/2\text{Ca}^{2+} + \text{Si}(\text{OH})_4$	

\*Solid phases are underlined.

Source: Freeze & Cherry, Table 7.4



## Acid Neutralization Capacity

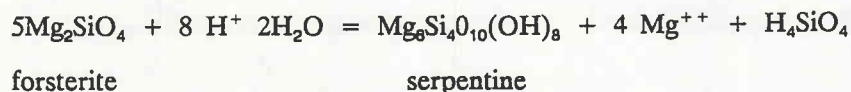
The measure of soil and rock's capacity to react with and neutralize acids is commonly referred to as its acid neutralization capacity (ANC). ANC is controlled by three factors: 1) the mineral's ability to accept  $H^+$  ions, 2) mineral solubility, and 3) mineral dissolution reaction kinetics (Norton, 1980).

Mineral Ability to Accept  $H^+$  Ions - The following three mineral families deserve consideration in the analysis of ANC: 1) aluminum and iron hydroxides, 2) aluminum, magnesium, and iron silicates, and 3) calcium and magnesium carbonates (Norton, 1980). Hydroxide minerals are relatively less common than other rock forming minerals and are typically formed as the weathering byproducts of parent aluminum and iron silicate minerals (Hurlbut & Klein, 1977, pp. 287-287). In the field they occur primarily in residual soils derived from parent Al and Fe silicate rocks, though they are known to occur in minor amounts as cementing agents in some sedimentary rocks. Little quantitative data are available on the dissolution rates of hydroxides, though Kramer (1976) considered goethite,  $FeO \cdot OH$ , a significant  $H^+$  ion sink. Because the alkalinity of most natural waters is due to  $HCO_3^-$  and  $CO_3^{2-}$ , and not  $OH^-$  (Drever, 1982), and because of the general lower occurrence and concentration of hydroxides in the earth's crust, the focus of this discussion will be on the silicate and carbonate mineral families.

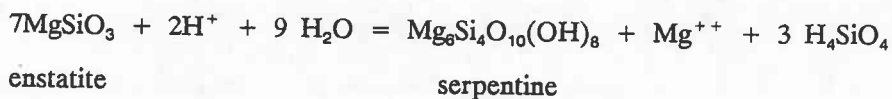
Silicate minerals constitute approximately 90% of the earth's crust (Hurlbut & Klein, 1977, p. 336.). Though the silicates are divided into several classes based on crystalline structure, two major groups contain the majority of the rock forming minerals: 1) the felsic or light colored silicate minerals such as feldspar, mica, aluminosilicate clays, and quartz, and 2) the mafic or dark colored minerals such as pyroxene, olivine, and amphiboles (Mg, Fe silicates). The felsic minerals (feldspar and quartz) are by far the most predominant of the silicate minerals, comprising nearly 75% of the earth's rocky crust (Hurlbut & Klein, 1977).

The dissolution reactions for many of the aluminosilicates are known and are listed in Table 1. All of these reactions consume  $H^+$  ions, thus the dissolution or weathering of aluminosilicate minerals buffers acid from both natural and anthropogenic sources. Quartz unfortunately, does not consume  $H^+$  ions in dissolution and therefore does not render ANC (Norton, 1980).

The mafic silicate minerals, olivine and pyroxene, most commonly occur as their Mg rich varieties forsterite ( $Mg_2SiO_4$ ) and enstatite ( $MgSiO_3$ ), respectively, in mafic and ultramafic rocks (Hurlbut & Klein, 1977 pp. 345 & 375). The chemistry of amphiboles, though known, is complex and variable, thus amphibole dissolution will receive only cursory attention here. Forsterite olivine dissolves to form serpentine as a mineral by-product, as shown by Hem (1970, p. 141):

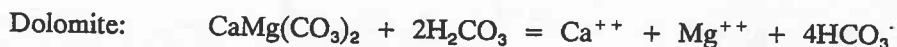


Enstatite proxene also incongruently dissolves to produce clay-like serpentine (Hurlbut & Klein, 1977, p. 401), and may do so by the reaction:



Amphiboles also weather incongruently to produce serpentine, assumably by a similar process (Hurlbut & Klein, 1977, p. 401). As can be seen above, the most common varieties of olivine and pyroxene do accept  $H^+$  ions in the dissolution process. Due to their chemical similarities, it is expected that the Fe-rich varieties of these minerals and amphiboles also provide ANC. In nature, the dissolution of silicate rocks, primarily by dilute concentrations of  $H_2CO_3$ , produces  $HCO_3^-$  type waters, thereby providing alkalinity (Freeze & Cherry, 1979, p. 268). As can be deduced above, in the case of silicate rock weathering the ultimate source of the  $HCO_3^-$  alkalinity is atmospheric  $CO_2$ .

Carbonate mineral dissolution varies from that of the silicate minerals in that  $\text{HCO}_3^-$  is not only produced from atmospheric  $\text{CO}_2$ , but is also derived from the carbonate rock. The following dissolution equations for calcite,  $\text{CaCO}_3$ , and dolomite,  $\text{CaMg}(\text{CO}_3)_2$ , the most common carbonate minerals, illustrate this point.



In nature, during the dissolution of carbonate minerals by  $\text{H}_2\text{CO}_3$  as shown above, equal amount of carbonate ( $\text{CO}_3^{2-}$ ) are provided by the rock and the atmosphere resulting in twice the amount of  $\text{HCO}_3^-$  available in the water for ANC after dissolution. This is one of the reasons why carbonate minerals are considered the best sources of ANC.

**Mineral Solubility** - Mineral solubility is affected by various factors such as pH, temperature, and solute ionic composition. In order to understand how much alkalinity a mineral can contribute to a solution it is useful to compare relative solubilities under standard conditions. Table 2 below lists solubilities for some common rock forming minerals that dissolve congruently.

As can be seen Table 2, quartz is the least soluble mineral, while halite, or rocksalt, is the most soluble. Calcite and dolomite have moderate solubilities, which increase in the presence of  $\text{CO}_2$  ( $\text{H}_2\text{CO}_3$ ) or low pH environments. The solubilities of the common felsic and mafic silicate minerals are much more complex, and are not listed in Table 2 because they dissolve incongruently (see Table 1). Chemical similarities with quartz, and geologic field observations, however, suggest that these silicate minerals probably have solubilities greater than quartz and less than the carbonate minerals calcite and dolomite.



Table 2. Dissociation Reactions, Equilibrium Constants, and Solubilities of Some Common Minerals That Dissolve Congruently in Water at 25°C and 1 Bar Total Pressure

Mineral	Dissociation Reaction	Equilibrium constant, $K_{eq}$ *	Solubility at pH 7 (mg/l)
Quartz	$\text{SiO}_2 + 2\text{H}_2\text{O} = \text{Si}(\text{OH})_4$	$10^{-3.7}$	12
Amorphous silica	$\text{SiO}_2 + 2\text{H}_2\text{O} = \text{Si}(\text{OH})_4$	$10^{-2.7}$	120
Flourite	$\text{CaF}_2 = \text{Ca}^{2+} + 2\text{F}^-$	$10^{-9.8}$	160
Dolomite	$\text{CaMg}(\text{CO}_3)_2 = \text{Ca}^{2+} + \text{Mg}^{2+} + 2\text{CO}_3^{2-}$	$10^{-17.0}$	90**, 480***
Calcite	$\text{CaCO}_3 = \text{Ca}^{2+} + \text{CO}_3^{2-}$	$10^{-8.4}$	100**, 500***
Gypsum	$\text{CaSO}_4 \cdot 2\text{H}_2\text{O} = \text{Ca}^{2+} + \text{SO}_4^{2-} + 2\text{H}_2\text{O}$	$10^{-4.5}$	2100
Sylvite	$\text{KCl} = \text{K}^+ + \text{Cl}^-$	$10^{+0.9}$	264,000
Halite	$\text{NaCl} = \text{Na}^+ + \text{Cl}^-$	$10^{+1.8}$	360,000

\* Relationship between mineral solubility and equilibrium constant described in Freeze and Cherry, 1977, p. 107.

\*\* Partial pressure of  $\text{CO}_2 = 10^{-3}$  bar.

\*\*\* Partial pressure of  $\text{CO}_2 = 10^{-1}$  bar.

Source: Freeze & Cherry, 1977, Table 3.6.

**Mineral Dissolution Kinetics** - The rate at which a mineral is dissolved is an important factor to consider in ANC analysis. Because surface water and ground water flow systems are in dynamic motion, the rate at which a mineral can produce alkalinity by  $\text{H}^+$  ion consumption controls how effective it will be in providing ANC. Laboratory studies suggest that the rates of dissolution for aluminosilicate minerals are very slow, as long as 1,000's of hours (Freeze and Cherry, 1979, p. 274). A closer look into this dissolution process indicates that it occurs in several stages. The first stage, and most important for ANC, involves a rapid exchange of  $\text{H}^+$  ions in the water for cations at the mineral's surface. In laboratory experiments this stage lasted for approximately one minute (Drever, 1982, p. 135). Any further exchange of aqueous  $\text{H}^+$  ions for mineral bound cations may be limited by the dissolution of silicate anions in the crystalline lattice, however this apparent rate-controlling process of aluminosilicate dissolution is poorly understood (Drever, 1982, p. 137). The low kinetics of aluminosilicate mineral dissolution correlate well with the low ionic concentration of waters commonly derived from felsic igneous and metamorphic terrains (Freeze and Cherry, 1977, p. 275).

The dissolution kinetics of mafic silicate minerals are also poorly understood. Laboratory research indicates that they dissolve in multi-stage process, the first stage of which also consists of a surface exchange of  $\text{H}^+$  ions for metal cations in the mineral (Drever, 1982, p. 129). The dissolution rate (kinetics) of mafic silicates is higher than their felsic counterparts as shown by the higher Total Dissolved Solids (TDS) content and alkalinity of waters derived from mafic rock terrains (Drever, 1982, p. 192). Perhaps this is caused by the higher metal content typical of mafic minerals providing more sites for  $\text{H}^+$  ion exchange.

Mineral surface area is another factor affecting the ANC of silicate rocks. Volcanic rocks are composed of much smaller minerals due to their shorter cooling histories. This smaller crystal size provides more surface area per unit rock mass for dissolution reactions to occur. Consequently, extrusive igneous rocks (i.e. volcanic rocks) tend to weather faster, and appear to provide more ANC per unit time than their chemically equivalent intrusive counterparts.

Carbonate dissolution is congruent, meaning that no solid phase mineral by-products are produced during dissolution, and well understood. The reaction kinetics are very rapid with  $H^+$  ion consumption complete within moments of contact. No rate controlling factors govern the reaction, only the amounts of carbonate and  $H^+$  ions available. This is important in dynamic water systems because the reaction is able to provide alkalinity (ANC) to water immediately, even under high flow conditions.

ANC Classification System - Based on the concepts developed above, a system was developed to classify regional watersheds within Utah based on whether the bedrock geology is conducive to producing low or high alkalinity waters, and hence providing low or high ANC (see Table 3). This system, modified after Norton, 1980, consists of two opposing end-members: rocks that do not accept  $H^+$  ions (Type 1), and those that do at very high reaction rates (Type 4).

Type 1 rocks do not buffer acids. These rocks, having no free carbonate phase, are predominantly composed of the minerals quartz, amorphous silica, gypsum, anhydrite, and halite, include quartz sandstones and quartzites, gypsum, anhydrite and halite. Other less common rock forming minerals that do not accept  $H^+$  ions may be included here.

Type 2 rocks have a low to moderate acid buffering capacities. They are composed predominantly of the aluminosilicate minerals feldspar, mica, and clay having no free carbonate phases. For the most part, these include felsic to intermediate igneous rocks, both intrusive and extrusive, and aluminosilicate based clastic sedimentary rocks, including arkoses and shale. The volcanic species of the igneous rocks mentioned here may provide more ANC than their intrusive counterparts, but are included in Type 2 based on their similar rock chemistry. Glassy members of this volcanic rock family may be included in Type 3. Metamorphic equivalents of all these rocks are also included here.

### Table 3. Utah Bedrock Acid Neutralization Capacity Classification System

Type 1 - no buffering capacity; do not accept  $H^+$  ions, no free carbonate phases. Common minerals = quartz, amorphous silica, gypsum, anhydrite and halite.

#### Rock Types

- Quartz sandstones and metamorphic equivalents
- Chert, and other forms of amorphous silica and metamorphic equivalents
- Gypsum, anhydrite, and halite (evaporite deposits)

Type 2 - low to moderate buffering capacity; accept  $H^+$  ions, but limited by low dissolution kinetics, no free carbonate phases. Common minerals = feldspar, mica, and clay (aluminosilicates).

#### Rock Types

- Felsic to intermediate igneous rocks and metamorphic equivalents.
  - a) intrusive: syenite, monzonite, diorite, granite, quartz monzonite, granodiorite, quartz diorite
  - b) extrusive: trachyte, trachyandesite, andesite, rhyolite, rhyodacite, dacite
- Clastic sedimentary rocks derived from felsic to intermediate igneous rocks, primarily arkosic sandstones and conglomerates; and their metamorphic equivalents (no free carbonates).
- Shales (no free carbonates)

Type 3 - moderate to high buffering capacity; accept  $H^+$  ions, but limited by moderate dissolution kinetics or low carbonate mineral content. Common minerals = olivine, pyroxene, amphibole (Mg & Fe silicates), minor plagioclase, or calcite, aragonite, or dolomite cements.

#### Rock Types

- Mafic to ultramafic igneous rocks and metamorphic equivalents.
  - a) intrusive: gabbro, leucogabbro, peridotite, dunite, and pyroxenite
  - b) extrusive: basalt
- Calcareous rocks, primarily clastic sedimentary rocks with minor amounts of carbonate cements of less than 50% bulk rock weight.

Type 4 - very high buffering capacity; minerals accept  $H^+$  ions with high dissolution kinetics; high carbonate mineral content, greater than 50% bulk weight. Common minerals = calcite and dolomite.

#### Rock Types

- Carbonate sedimentary rocks and metamorphic equivalents
  - a) limestone
  - b) dolomite
  - c) marble

Type 5 - unknown buffering capacity; bedrock covered by thick unconsolidated deposits requiring further investigation to determine lithology and ANC.

Type 3 rocks have a moderate to high buffering capacity. They are composed predominantly of the mafic silicate minerals olivine, pyroxene, and amphibole, or have low concentrations of carbonate minerals, primarily as cements. Low concentrations of carbonate cements, perhaps less than 1% total weight, can exert a strong influence on ground water chemistry, and hence provide some ANC (Freeze and Cherry, p. 256). Rocks of this type include the igneous intrusive gabbro, leucogabbro, peridotite, dunite, and pyroxenite, the extrusive basalt; and clastic sedimentary or other rocks with small concentrations of carbonate cements. Metamorphic equivalents are also included here.

Type 4 rocks have very high acid buffering capacities and are composed predominantly of the carbonate minerals calcite, and dolomite. For the purpose of this classification system, Type 4 rocks contain  $\geq 50\%$  carbonate minerals by bulk weight. All varieties of carbonate rocks are included here: tufa, travertine, fossiliferous limestone, crystalline limestone, oolitic limestone, and many others. Metamorphic equivalent marble is also included.



### Bedrock ANC Map

A bedrock ANC map of Utah has been produced using the ANC classification system described above (see Figure 1). Several prominent geographic/geologic features are worthy of noting here, and are listed below by ANC type.

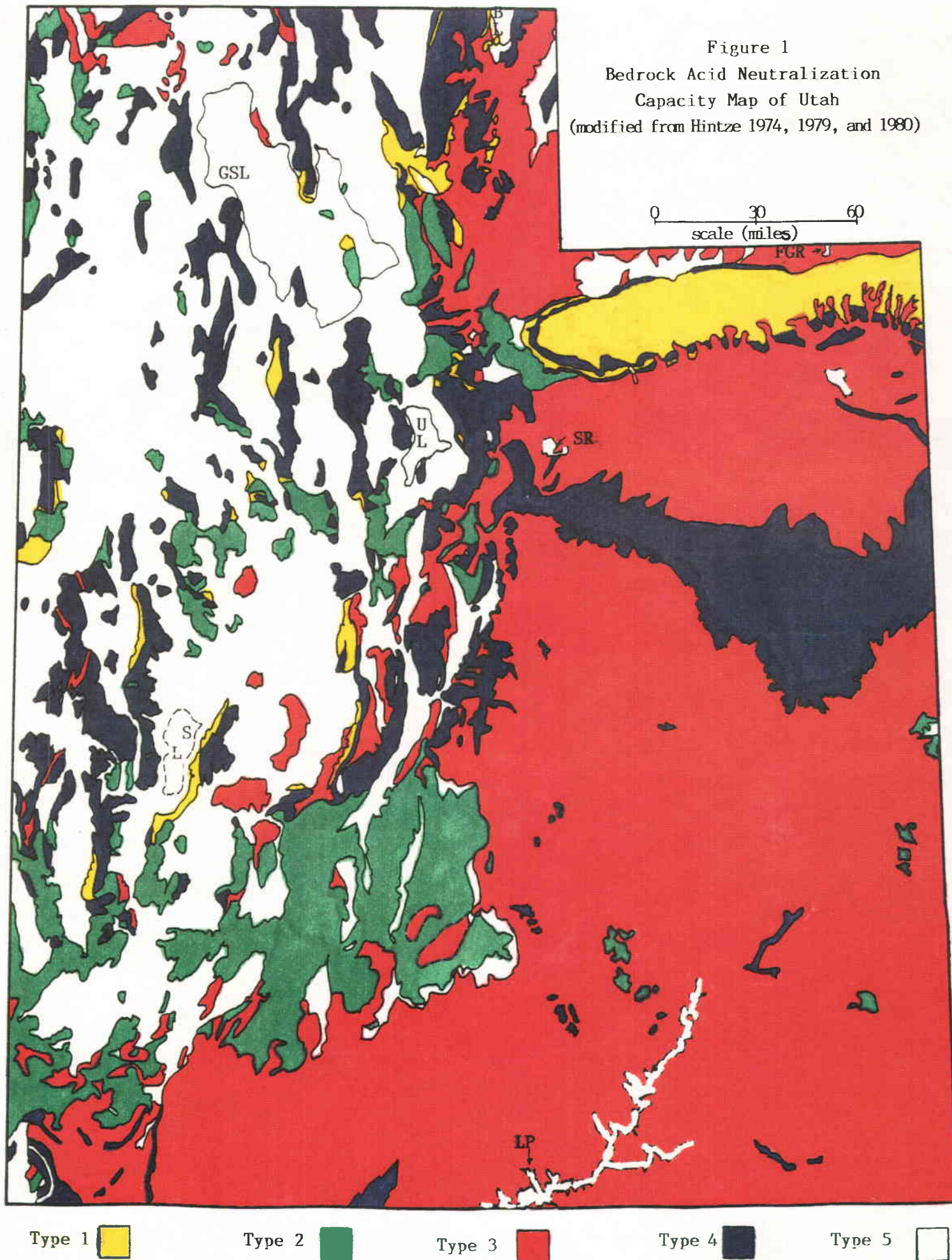
Type 1 Terrains - These watersheds are characterized by quartzite terrains of early Cambrian and late Precambrian-age strata. They include the following mountain ranges, or parts thereof, and watersheds, which are listed by approximate locations and surface water type:

<u>Mountain Range/Watershed</u>	<u>Location</u>	<u>Surface Water Type</u>
1. Uinta Mountains	Summit, Duchesne, Uintah, and Dagget Counties	perennial lakes and streams
2. North Fork of the River	Weber County	perennial stream
3. West slope of the Stansbury Mountains	Tooele County	ephemeral streams
4. South end of the Deep Creek Mountains	Juab County	perennial and ephemeral streams
5. West slope of the House Range, west of Swasey Peak	Juab and Millard Counties	ephemeral streams
6. Canyon Mountains	Millard County	ephemeral streams
7. West slope of Cricket Mountains, and north end of the San Francisco Mountains	Millard and Beaver Counties	ephemeral streams
8. West slope of the Wah Wah Mountains	Beaver County	ephemeral streams

Other small quartzite outcrops are located on the map in Cache, Rich, Box Elder, Davis, Weber, Morgan, Utah, and Millard counties, but are omitted from the list above due to limited surface extent. However, on a local scale these areas may be worthy of consideration. Varying feldspar content in the quartzites might also effect ANC, consequently some of these watersheds may produce very small amounts of rock derived alkalinity.

Type 2 Terrains - These watersheds are characterized by felsic igneous and metamorphic rocks, of Precambrian, Jurassic, and Tertiary-age formations. These mountain ranges and watersheds are listed below with their approximate locations and surface water types:

Figure 1  
Bedrock Acid Neutralization  
Capacity Map of Utah  
(modified from Hintze 1974, 1979, and 1980)



Type 1  Type 2  Type 3  Type 4  Type 5

ANC Classification System (see table 3)





<u>Mountain Range/Watershed</u>	<u>Location</u>	<u>Surface Water Type</u>
1. Tushar, Mineral, and Black Mountains, and Markagunt, Sevier, Awapa, Aquarius, and Fish Lake Hightop Plateaus, and Boulder Mountain	Beaver, Millard, Sevier, Piute, Wayne and Garfield Counties	perennial and ephemeral streams
2. Southern end of the San Francisco Mountains and the Big Wash drainage west of Milford	Beaver County	ephemeral streams
3. Pine Valley and Bull Valley Mountains	Washington County	perennial and ephemeral streams
4. Southern end of Mountain Home Range and Indian Peak Range	Beaver and Iron Counties	ephemeral streams
5. Southern end of the Wah Wah Mountains	Beaver and Iron Counties	ephemeral streams
6. Drum, Little Drum, and Keg Mountains and Thomas Range	Juab and Millard Counties	ephemeral streams
7. Simpson, Sheeprock, and West Tintic Mountains	Tooele and Juab Counties	ephemeral streams
8. East Tintic Mountains and Long Ridge	Juab and Utah Counties	ephemeral streams
9. Traverse Mountains, including Rose Canyon, Little Cottonwood Creek, and Lake Hardy watersheds	Salt Lake and Utah Counties	perennial and ephemeral streams
10. The West Hills and the Lady Long Hollow, Bench Creek, and Little South Fork tributary watersheds to the Provo River	Wasatch and Summit Counties	perennial and ephemeral streams
11. Wasatch Mountains, from west slope of Mt. Ogden to south of Bountiful Peak, and from east slope of Mt. Ogden to Porterville	Davis and Morgan Counties	perennial and ephemeral streams
12. Deep Creek Mountains, between Tom's and Granite Creek drainages	Juab County	perennial and ephemeral streams

13. Portions of Goose Creek, Grouse Creek Mountains and Pilot Range	Box Elder County	perennial and ephemeral streams
14. Colorado River, Westwater Canyon, and Coates Creek drainages	Grand County	perennial and ephemeral streams
15. La Sal Mountain highlands	Grand and San Juan Counties	perennial and ephemeral streams
16. Abajo Mountain highlands	San Juan County	ephemeral streams
17. Henry Mountain highlands	Garfield County	ephemeral streams

Since these watersheds are composed of crystalline rocks, fracture dominated ground water flow will be a significant factor in determining ANC. Highly fractured watersheds will typically have lower ground water residence times, thereby possibly limiting rock-water reactions and producing lower ANC.

Type 3 Terrains - These watersheds were characterized by mafic volcanic and metamorphic rocks, and/or carbonate cemented sedimentary rocks or Precambrian, Paleozoic, Mesozoic, and Tertiary-age strata. These include the following mountain ranges and watersheds which are listed below by their approximate locations and surface water types:

<u>Mountain Range/Watershed</u>	<u>Location</u>	<u>Surface Water Type</u>
1. Colorado Plateau, including much of the Santa Clara & Virgin River basins, the Kolob Terrace, Pink Cliffs, White Cliffs, Kaiparowits Plateau, Circle Cliffs, San Rafael Swell, Castle Valley, Wasatch Plateau, Book Cliffs, San Rafael Desert, Grand Valley, Canyonlands, and the Four Corners Area	Washington, Kane, Garfield, Wayne, Sevier, Emery, Sanpete, Utah, Carbon, Grand, and San Juan Counties	perennial and ephemeral streams
2. Uintah Basin, north of the Badlands Cliffs and the East Tavaputs Plateau; south of the Uinta Mountains	Wasatch, Uintah, and Duchesne Counties	perennial and ephemeral streams
3. Wasatch Range, north of Wanship, east of Huntsville and east of the Logan River; also north slope of the Uinta Mountains	Summit, Morgan, Weber, Cache, Rich, and Daggett Counties	perennial and ephemeral streams
4. Black Rock Pavant Butte, and Fumarole Butte	Juab and Millard Counties	ephemeral streams
5. Portions of the Pavant Range, and Canyon Valley, and San Pitch Mountains	Millard, Sevier, Sanpete, and Juab Counties	perennial and ephemeral streams



6. Portions of the Grouse  
Creek and Raft River  
Mountains

Box Elder County

perennial and  
ephemeral streams

These terrains have been classified here differently than by Norton, et.al., (1982) due to their free carbonate phase content, either as cements or as clasts in sedimentary rocks. This has dramatically changed previous ANC interpretations of the Colorado Plateau, which is now considered to have a moderate to high acid buffering capacity.

Type 4 Terrains - These watersheds are characterized by rocks of 50% or greater carbonate mineral content. This includes primarily limestones and dolomite strata. These terrains are outlined below:

<u>Mountain Range/Watershed</u>	<u>Location</u>	<u>Surface Water</u>
1. Bear River Range and Wellsville Mountain	Cache and Box Elder Counties	perennial and ephemeral streams
2. West Hills, Blue Spring Hills, North Promontory and Promontory Mountains	Box Elder County	ephemeral streams
3. Hogup, Newfoundland, Silver Island, and portions of Raft River and Goose Creek Mts.	Box Elder County	ephemeral streams
4. Lakeside, Grassy, Cedar, Stansbury, and Onaqu Mts.	Box Elder and Tooele Counties	ephemeral streams
5. Oquirrh, Lake, and portions East Tintic Mountains	Tooele and Utah Counties	ephemeral streams
6. Wasatch Range, including Mt. Nebo, Spanish Fork and Provo Peaks, and Mt. Timpanogos	Utah and Juab Counties	perennial and ephemeral streams
7. Portions of the San Pitch and Valley Mountains, and the Pavant Range	Sanpete, Juab, Millard, and Sevier Counties	perennial and ephemeral streams
8. West slope of Wasatch Plateau	Sanpete and Sevier Counties	perennial and ephemeral streams
9. Fish Springs, House, Confusion, northern Deep Creek, and Mountain Home Ranges, and Burbank Hills, Tunnel Spring, Wah Wah, and east slope of the Cricket Mountains	Tooele, Juab, Millard, and Beaver Counties	ephemeral streams
10. East slope of Beaver Dam Mountains, Hurricane Cliffs, and portions of Bull Valley and Pine Valley Mountains	Washington County	ephemeral streams
11. Buckskin Mountain	Kane County	ephemeral streams

- |   |  |                                 |
|---|--|---------------------------------|
| 12. Portions of Capitol Reef, Waterpocket Fold, and San Rafael Swell                                      | Wayne, Garfield and Emery Counties                         | ephemeral streams               |
| 13. Outcrops along the Colorado River (Cataract and Deep Canyons) and the San Juan River (The Goosenecks) | San Juan County  | perennial streams               |
| 14. Roan Cliffs, East and West Tavaputs Plateau, Soldier Summit, and Strawberry Ridge                     | Grand, Uintah, Carbon, Duchesne, Wasatch and Utah Counties | perennial and ephemeral streams |

These terrains, as outlined above and on Figure 1, are essentially non-sensitive to acid deposition because of their high bedrock carbonate mineral content.

Type 5 Terrains - These terrains are of unknown ANC due to thick cover by unconsolidated deposits of complex origin. These areas include:

<u>Mountain Range/Watershed</u>	<u>Location</u>	<u>Hydrology</u>
1. Alluvial basins of Western Utah	Box Elder, Cache, Weber, Davis, Salt Lake, Tooele, Utah Juab, Millard, Beaver, Iron, and Washington Counties	perennial and ephemeral streams
2. High mountain alluvial valleys	Rich, Weber, Summit, Wasatch, Uintah, Sanpete, Sevier, Piute and Garfield Counties	perennial and ephemeral streams
3. Glacial terrains on the north slope of Uinta Mountains, and east and south slopes of the Aquarius Plateau	Summit, Garfield, and Wayne Counties	perennial and ephemeral streams

The alluvial basins of western Utah are composed primarily of alluvial fans which have filled the fault dropped valleys. The alluvial material has been derived from the adjoining upfaulted mountain blocks. ANC can be determined for the materials only after an investigation of soil/alluvium lithology and stratigraphy.

The high mountain alluvial valleys typically have been filled with detritus derived from the nearby mountains. However, many valleys contain extensive river systems, which can import alluvial detritus from areas located several tens of miles away. Consequently, detailed lithologic and stratigraphic studies would be required of these valleys in order to determine ANC. However, in general the alluvial basins or high mountain valleys would be expected to have similar ANC as the watersheds from whence the alluvium was derived.

The glacial materials found on the north slope of the Uinta Mountains and along the margin of the Aquarius Plateau were derived from their adjoining highlands and transported to their present location by alpine glaciers and related outwash streams. Due to short distances and type of transport, it is expected that these deposits have similar ANC as their parent bedrock materials. Other alpine glacier deposits exist in the State at elevations above 9,000 feet, but for simplicity have not been illustrated in Figure 1. However, detailed ANC studies, on an individual watershed basis, should account for these deposits.



## Conclusion

A bedrock ANC classification system has been presented here, modified from the work of researchers in the eastern United States. This system, tailored for use with rocks common to Utah, has been designed for use as a predictive tool to locate watersheds that lack the ability to provide significant amounts of alkalinity to water, or ANC.

Stratigraphic data compiled by local researchers from various areas of the State have been reviewed and analyzed in the production of a bedrock ANC reconnaissance map. Most striking is that the map indicates several mountain ranges which are composed of watersheds, in whole or in part, with no or very little ANC, the largest of which is the Uinta Mountains. Here, mountain ranges are found with no, to vary high ANC. The map also shows that:

1. The diverse stratigraphy and complex geologic structure of western Utah produces a region of varied ANC.
2. The felsic volcanic fields of southwestern Utah appear to have provided terrain that has low to moderate ANC.
3. The vast Colorado Plateau is composed primarily of carbonate cemented clastic sedimentary rocks that provide moderate to high ANC. The same is true of the Uinta Basin, which is separated from the Colorado Plateau by broad outcrops of predominantly high ANC carbonate sedimentary rocks of the Flagstaff and Green River Formations.
4. The Wasatch Range, east and south of Bear Lake, and north of the Uinta Mountains is blanketed by carbonate cemented sedimentary rocks that may also provide moderate to high ANC.

A word of caution must be offered to those using this information. The purpose of this study was to accomplish a preliminary ANC survey to watersheds across the state and to focus attention on priority areas worthy of further study. Due to the scale of this study several factors have been ignored, which must be considered particularly in the course of detailed studies or interpretation of water chemistry data from individual watersheds. These are outlined below.

1. Local hydrogeologic factors including:
  - a) The presence, thickness, lithology, and permeability of soils.
  - b) Watershed hydrology, i.e., analysis of the water budget and temporal behavior of drainage basins, including a determination of the source of inputs and fate of outputs from an individual watershed system.
  - c) Stratigraphic complexities of geologic formations. Formations of multiple lithologies have been classified here by their dominant rock type. On a local scale however, varied rock lithologies within a formation can dramatically effect water chemistry and ANC. Also, individual rock strata with less than 50% carbonate mineral content (Type 3 rocks) may well provide nearly equivalent levels of ANC as Type 4 strata. Facies changes within a formation between watersheds can also effect ANC.
  - d) The flow path of the ground water in the watershed, as controlled by geomorphology, geologic relationships, and soil and rock permeability, may effect residence time in the subsurface and ANC. These factors can only be evaluated on a single watershed scale.
2. Land use practices can have a dramatic effect on ground and surface water quality and ANC.
3. Biologic effects of macro-and microbiota, and organic detritus can effect water chemistry and ANC.

### Recommendations

Freeze and Cherry (1979) indicate that even insignificant amounts of minerals may exert strong influences on ground water chemistry. This may indicate that even very small amounts of carbonate may contribute more to the formation of ANC than predicted in this paper. If this proves to be correct, the carbonate percentages used as cut off points for ANC types III and IV in Table 3 may have to be revised. In any event, detailed hydrogeologic studies of individual basins and extensive literature research should be completed to more fully understand the relationship of hydrogeology to ANC. This classification system, as it stands, however, provides a solid base for predicting areas in Utah which are potentially sensitive to acid deposition.

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# UTAH 1987 HIGH ELEVATION STREAM AND LAKE SAMPLING PROGRAM

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## INTRODUCTION

In 1986 the Acid Deposition Technical Advisory Committee recommended that reconnaissance surveys be conducted in areas considered potentially sensitive to acid deposition. In response to this recommendation, a cooperative agreement involving private individuals, Kennecott Corporation, and several state and federal agencies was developed and approved. This agreement organized efforts to sample selected streams and lakes in ten different mountain ranges in Utah during the summer of 1987. The water chemistry data were then used to determine the Acid Neutralizing Capacities (ANC) of the sampled lakes and streams and, consequently, their sensitivities to acid deposition.

### Site Selection

Criteria for site selection included elevation near or greater than 10,000 ft. above sea level, steep terrain, thin soils, exposed bedrock, remoteness from anthropogenic activity, accessibility, and the existence of other baseline data such as geologic or fishery information.

### Sampling Protocol

Samples were collected and preserved according to guidelines established in the Utah Water Quality Monitoring Manual (Section 3). In addition, field data for temperature, pH, specific conductance, dissolved oxygen content, and flow were also collected if possible. Field pH and conductivity values were compared to laboratory values as a double check since these two components are directly related to acid deposition.

### Laboratory Analysis

After collection, samples were transported to either Kennecott's Environmental/Industrial Hygiene Lab. Analytical methods used were derived from the 16th Edition of Standard Methods. Specifically, the carbonate, bicarbonate, carbon dioxide, and hydroxide data were determined from nomographs on pages 281-286. Field pH and temperature measurements were used when available, otherwise laboratory data were substituted. Laboratory analyses included major cations and anions, dissolved metals, nutrients, and other constituents. Cation and anion balances were done on each sample as a supplemental quality assurance.

### Data Evaluation

The main water chemistry parameters necessary to determine sensitivity to acid deposition include total alkalinity, pH, carbonates, bicarbonates, carbon dioxide, conductivity/total dissolved solids, and calcium and magnesium. For most surface water  $\text{Ca}^+$  and  $\text{Mg}^+$  are the major base cations and  $\text{HCO}_3^-$  (bicarbonate) is the dominant anion (Rodhe, 1949).

The water quality analysis for each mountain range will concentrate on these parameters, but will also briefly review data for total dissolved metals and nutrients. Abnormal or elevated values may be referenced to State standards or EPA's Quality Criteria for Water (EPA, 1976).

### Acid Neutralizing Capacity - ANC

The Acid Neutralizing Capacity (ANC) of a substance, defined as the capacity of a substance to react with and neutralize an acid, is determined by the following formula:  $\text{ANC in microequivalents/liter (ueq/l)} = \text{total alkalinity in g/ml} \times 20$ . EPA has defined reference values for determining the sensitivity of waters in the following way:

1. ANC values of less than or equal to 0 ueq/l are defined as "acidic".
2. An ANC value of 50 ueq/l represents low ANC.
3. An ANC value of 200 ueq/l is used at the criteria to separate lakes that may be sensitive to acid deposition from lakes which may not be with less than 200 ueq/l indicating sensitive, and greater than 200 ueq/l non-sensitive.

A numerical value for ANC's of less than 200 ueq/l could not be determined from this study because the laboratory minimal detection limit (MDL) for total alkalinity, and consequently ANC, was 10 mg/l or an ANC of 200 ueq/l. Values below these amounts can only be listed as less than 10 mg/l or less than 200 ueq/l. This indicates that the degree of sensitivity of a lake cannot be determined by this data - only whether a lake is sensitive or non-sensitive.

In spite of this limitation, ANC values derived from the water data will be compared with the bedrock ANC's, as presented in Loren Morton's paper, Bedrock Acid Neutralization Capacity and Its Role in Predicting Sensitive Watersheds in Utah (see previous paper).

### Fishery Classification System - General Definitions of Class I, II, III, IV, V, and VI Streams:

Class I - streams support the highest quality stream fisheries in Utah, and are the best of the blue ribbon waters. They should be preserved and improved for fishing and related recreation. These streams are typically outstanding in natural beauty and are truly unique. They are accessible by automobile, and the larger streams are floatable. Productivity of game fish is very high. Natural reproduction and/or stocking of small fish maintains an excellent sport fishery. At the present, only 70 miles of Class I stream exist in Utah.

Class II - streams are of great importance to the State fishery, and may also be considered blue ribbon quality. These are productive streams with high esthetic value and should be preserved. Fishing and other recreational uses should be the primary consideration. They are moderate to large in size and may have some human development along them. Many Class II streams are comparable to Class I except for size. There are only 302 miles of Class II stream in Utah.

Class III - streams comprise about half of the total stream fisheries in Utah. These waters are important because they support the bulk of our stream fishing. Water development involving Class III waters should be planned to include fisheries as a primary use, and fishery losses should be prevented, or enhanced when possible. There are 3,864 miles of Class III stream in Utah.

Class IV - streams are typically poor in quality, with limited sport fishing value. Fishing should be considered a secondary use. A few Class IV fisheries support catchable-size hatchery trout in areas where few other fisheries exist. Water development plans should include proposals to enhance fisheries values where feasible. There are 1,893 miles of Class IV stream in Utah. The few Class IV streams usually support federal or State fish species that are threatened, endangered or of special management concern.

Class V - streams in their present state are practically valueless as fisheries. Other water uses might take preference over fisheries use in planning water developments. However, many Class V streams could provide valuable fisheries if additional water or physical habitat improvement were provided. There are 726 miles of Class V stream in Utah.

Class VI - streams are those stream channels which are dewatered for significant periods of the year. Many of the stream reaches now in this class could support good-to-excellent fish populations if appropriate minimum flows were provided. Planning of water developments should include consideration for restoration of these dewatered sections of stream.

The following sections present the results of the 1987 Lake and Stream Sampling Program.

## **BOULDER MOUNTAIN**

### **Site Descriptions**

Crescent Lake is located on the southern rim of the Aquarius Plateau in T.31S, R.4E, Sec. 29, at an elevation of 10,800 ft. There are no apparent inflow streams, therefore all lake water is from either surface runoff or ground water. A small stream which flows into the West Fork of Boulder Creek exits the lake along its south shore. Surface grab samples were taken near this outlet.

Donkey Lake is located below the northern rim of the Aquarius Plateau in T.30S, R.4E, Sec. 17, at 10,250 ft. The lake has no inflow tributaries, therefore all lake water is also derived from either surface runoff or ground water. The headwaters of Donkey Creek exit the lake on its northeast shore and flows northward. Surface grab samples were taken near this outlet.

Donkey and Crescent Lakes were sampled by the Utah Bureau of Water Pollution Control staff.

### **Water Chemistry**

Crescent Lake was sampled on August 6, 1987 and again on October 14, 1987. Donkey Lake was only sampled on October 14, 1987. The water chemistry data show that the two lakes exhibit different physical and chemical profiles. Crescent, located on the Aquarius Plateau, is supplied mostly from snow melt and groundwater; pH values were near neutral (6.9 and 7.0). Field conductivities were measured at 29 umhos/cm and 42 umhos/cm, but lab readings were lower at 13 umhos/cm and 12 umhos/cm. Dissolved oxygen was somewhat low at 6.1 ppm. Laboratory results indicate the acid neutralizing capacity (ANC) of the lake was  $\leq 200.0$  ueq/l. Bicarbonates were very low with readings of 20 mg/l and 10 mg/l. The major base cations,  $\text{Ca}^+$  and  $\text{Mg}^+$ , had low readings: 1.0 mg/l respectively. All other anions and cations values were very low. Nitrogen and phosphorus were below detectible limits.

Donkey Lake, located below the north rim of the Aquarius Plateau, demonstrated significantly different water quality than Crescent Lake. Donkey Lake's lab pH was measured at 9.1, and its ANC value of 880.0 ueq/l indicates that it has a greater buffering capacity than Crescent Lake. The bicarbonate value was 44.0 mg/l. The major base cations, Ca and Mg, had moderate readings: Ca 1.0-9.1 mg/l and Mg .3-29 mg/l. Other anions and cations value were moderate, most at or above MDL.

The chemistry data indicate that Crescent Lake, with an ANC of 200 ueq/l, is potentially sensitive to acid deposition. In contrast, the data indicate that the waters of Donkey Lake, with an ANC of 880 ueq/l at the time of the sampling, are probably not sensitive to acid deposition (Table 1). The Aquarius Plateau/Boulder Mountain area is predicted to be a Type 2 Terrain, indicating low to moderate ANC. The ANC value for Crescent Lake, located on the Aquarius Plateau, agrees with this prediction. Donkey Lake, on the other hand, is located on Quaternary glacial alluvium (Type 5 terrain) whose ANC can only be determined through a detailed geologic evaluation.



### Fisheries

Crescent Lake supports a stocked cutthroat trout (Salmo clarki) population. It is stocked during even years with cutthroat fry which show good survival. It is rated a Class 3 fishery. The fishery of this lake was last surveyed August, 1983.

Donkey Reservoir, last surveyed June, 1982 supports a stocked cutthroat trout and brook trout (Salvelinus fontinalis) fishery. It is considered to be Class 3 fishery.

# BOULDER MOUNTAIN

Table 1.

1987	<u>Crescent Lake</u>		<u>Donkey Lake</u>
	8/6	10/14	10/14
<u>Physical Measurements</u>			
Field pH		8.6	6.8
Lab pH	6.9	7.0	9.1
Field Cond. (umhos/cm)	29.0	42.0	101.0
Lab Cond. (umhos/cm)	13.3	12.0	75.0
Field Temp. (°C)		7.2	8.1
Field DO (ppm)		6.1	7.3
<u>Laboratory Results*</u>			
ANC (ueq/l)	≤ 200.0	≤ 200.0	880.0
Total Alk.	10.0	10.0	44.0
TSS	.2	6.8	1.8
TDS	23.0	21.0	63.0
SO <sub>4</sub>	5.0	5.0	5.0
Cl	1.0	1.0	1.0
Hardness	10.0	10.0	31.0
CO <sub>3</sub>	.5	.5	.5
HCO <sub>3</sub>	20.0	10.0	44.0
CO <sub>2</sub>	8.0	.1	16.0
OH	.5	.5	.5
Na	.4	1.0	2.0
K	.5	.4	.9
Ca	1.0	1.0	9.1
Mg	.4	.3	2.9
Cu	.01	.01	.01
Fe	.03	.18	4.5
Al	.1	.1	.1
Mn	.01	.01	.02
Pb	.004	.005	.005
Zn	.01	.01	.01
As	.009	.008	.005
Se	.004	.004	.004
Ag	.01	.01	.01
Cd	.01	.005	.005
Ba	.01	.01	.01
Ni	.01	.01	.01
Cr	.01	.01	.01
Hg	.0001		.01
TOC	24.0	3.1	2.3
NH <sub>3</sub>	.05	.07	.11
NO <sub>2</sub>	.02	.02	.02
NO <sub>3</sub>	.02	.2	.2
PO <sub>4</sub>	.02	.02	.02
TP	.1	.1	.1

\*MG/L except ANC



## DEEP CREEK MOUNTAINS

### Site Descriptions

Birch Creek originates on the east slope of the Deep Creek Mountains at an elevation of about 10,000 ft. The stream flows south and then west to the valley floor. Due to limited accessibility, the stream was not sampled at its headwaters, but near its 9,000 ft. elevation in T. 12S., R. 19W., Sec. 26. The stream is perennial but flow rates are influenced by climatic conditions; flows were minimal when sampled.

Trout Creek also originates along the east slope at the Deep Creek Mountains but flows south and east to the valley floor. Again, due to limited accessibility, its 10,600 ft. headwaters could not be sampled. The sampling location was at 9,200 ft. in T. 12S., R. 19W., Sec. 12. The stream is perennial and influenced by climatic conditions; flows were minimal when sampled.

Birch and Trout Creeks were sampled by Bureau of Land Management personnel according to standard sampling procedures.

### Water Chemistry

Birch and Trout Creeks were sampled on both 7-8-87 and 10-14-87. Physical parameters indicate waters with a pH's slightly above or below neutral (from 6.0 to 8.0), low lab conductivities (from 34-40 umhos/cm), and high dissolved oxygen contents (8.0-10.0 ppm).

Laboratory results for Birch Creek indicate an acid neutralizing capacity (ANC) of 300 ueq/l on both sampling dates, and very low bicarbonate readings (24 mg/l and 15 mg/l). ANC values of Trout Creek were  $\leq$  200 ueq/l and 290 ueq/l. Bicarbonates values were 20 mg/l and 14.5 mg/l. Other anions for both samples were very low. The major base cations read: Ca 2.5 - 4.0 mg/l and Mg 1.0 - 1.2 mg/l. All other anions and cations values were very low or at MDL. Nitrogen and phosphorus values were minimal or at MDL.

The chemistry data indicate that Trout Creek (ANC = 200 ueq/l and 290 ueq/l) may be sensitive to acid deposition while Birch Creek (ANC = 300 ueq/l) is probably not (Table 2). The area where these samples were collected is predicted to be a Type 1 terrain having no buffering capacity.

### Fisheries

Birch Creek is made up of one section which was last surveyed in 1975. It is rated a Class 3B fishery, containing important spawning and nursery habitat. Birch Creek contained a hybridized Bonneville cutthroat trout population. This population was eradicated in 1978 and the stream restocked with pure Snake Valley Bonneville cutthroat trout. Reproduction and survival of the fish has not been verified as yet.

Trout Creek is also considered as one stream section in its entirety. This stream was last surveyed in 1974 and is also considered a Class 3B water with a naturally-reproducing Snake Valley Bonneville cutthroat trout population, above a barrier falls. Hybridized trout were removed from below the falls and this area was restocked with the Snake Valley cutthroat in 1978.

# DEEP CREEK MOUNTAINS

Table 2.

1987

	<u>Birch Creek</u>		<u>Trout Creek</u>	
	7/8	10/1	7/8	10/4
<u>Physical Measurements</u>				
Field pH	8.0	7.5	7.0	6.0
Lab pH	6.9	7.0	6.8	7.1
Lab Cond. (umhos/cm)	38.0	40.0	34.0	40.0
Field Temp. (°C)	6.7	5.6	6.1	4.4
Field DO (ppm)	8.0		10.0	
Flow (CFS)	.13	.1	.05	.01
<u>Laboratory Results*</u>				
ANC (ueq l)	300.0	300.0	≤200.0	290.0
Total Alk.	15.0	15.0	10.0	14.5
TSS	3.5	.2	5.6	1.5
TDS	26.0	35.0	21.0	28.0
SO <sub>4</sub>	5.0	5.4	5.0	5.2
CL	1.0	1.6	1.0	1.7
Hardness	15.0	12.1	12.0	13.5
CO <sub>3</sub>	.5	.5	.5	.5
HCO <sub>3</sub>	24.0	15.0	20.0	14.5
CO <sub>2</sub>	.4	1.3	6.2	32.0
OH	.5	.5	.5	.5
Na	1.2	2.0	1.1	2.0
K	.4	.3	.6	.5
Ca	4.0	3.3	2.5	2.5
Mg	1.2	1.1	1.0	1.0
Cu	.01	.01	.01	.01
Fe	.12	.06	.16	.15
Al	.10	.10	.40	.10
Mn	.01	.01	.01	.01
Pb	.004	.004	.005	.005
Zn	.01	.01	.01	.01
As	.004	0.01	.004	.004
Se	.004	.004	.004	.004
Ag	.01	.01	.01	.01
Cd	.01	.005	.01	.007
Ba	.01	.01	.01	.01
Ni	.01	.01	.01	.01
Cr	.02	.01	.01	.01
Hg	.0001		.0001	
TOC	13.0	2.0	10.8	1.4
NH <sub>3</sub>	.22	.05	.05	.05
NO <sub>2</sub>	.02	.02	.02	.02
NO <sub>3</sub>	.04	.2	.02	.2
PO <sub>4</sub>	.02	.02	.02	.02
TP	.10	.10	.10	.10

\* MG/L except ANC

## HENRY MOUNTAINS

### Site Descriptions

East and west slope streams of the Henry Mountains were sampled during this project. All of the the east slope creeks which were sampled, Crescent, Slate, Granite and Straight, flow easterly to the valley floor, are perennial, and are significantly influenced by climatic conditions.

Crescent Creek originates in Bromide Basin on Mt. Ellen near the 10,500 ft. elevation. It was sampled near the 10,000 ft. elevation in T. 31S., R. 10E., Sec. 34. Granite Creek originates near the 10,800 ft. elevation on Mt. Ellen and was sampled near the 9,000 ft. elevation in T. 31S., R. 10E., Sec. 26. Straight Creek originates near the 10,400 ft. elevation on Mt. Pennell and was sampled near its 8,100 ft. elevation in T. 33S., R. 10E., Sec. 12. Slate Creek originates on the southeast slope of Mt. Ellen near the 10,000 ft. elevation and was sampled near the 8,600 ft. elevation in T. 32S., R. 10E., Sec. 10.

Two westerly flowing streams were also sampled. Pistol Creek, a perennial stream significantly influenced by climatic conditions, originates on the west slope of Mt. Ellen near an elevation of 10,000 ft. and flows westerly into Dugout Creek. It was sampled in T. 31S., R. 10E., Sec. 20. South Creek originates on the southwest slope of Mt. Ellen near an elevation of 10,000 ft. and was sampled at 9,600 ft. in T. 32S., R. 10E., Sec. 33. It also flows westerly.

Utah Bureau of Water Pollution Control and Bureau of Land Management personnel sampled these locations according to standard procedures.

### Water Chemistry

All streams are high headwater streams above 8,400 ft. with low flows (.03-.4 cfs). The streams were sampled at various times in the summer of 1987 (see Table 3). Physical parameters indicate waters with pH's slightly below or above neutral (from 6.9 to 8.7), lab conductivities from 190-305 umhos/cm, and high dissolved oxygen content (8.0-9.4 ppm). Laboratory results indicate that the acid neutralizing capacity (ANC) of the creeks sampled ranged from 720 ueq/l - 1272 ueq/l. Bicarbonates were high with readings of 64 mg/l to 145 mg/l. Sulfates significantly influence these systems with high readings ranging from 14 mg/l -71 mg/l. Other anions in all streams were also moderate. The major base cations, Ca and Mg, had high readings: Ca<sup>+</sup> 31 to 58 mg/l and Mg<sup>+</sup> 3 to 6.2 mg/l. All other anions and cations values were above or at MDL. Nitrogen and phosphorus values were generally minimal or at MDL.

Elevated nitrate, phosphate, or ammonia levels seen in these samples may be attributed to climatic conditions.

The chemistry data indicates that all six streams are not sensitive to acid deposition, having ANC's ranging from 720 ueq/l to 3080 ueq/l (Table 3). Based on bedrock ANC this area is predicted to be a Type 2 terrain with low to moderate buffering capacities. A discussion of poor correlation between water ANC and predicted bedrock ANC can be found at the end of this paper.

### Fisheries

The six streams located on the Henry Mountains have not been surveyed as to their fishery value. It is known that Granite Creek contains a brook trout population and Crescent Creek has received an experimental stocking of fingerling brook trout this year (Walt Donaldson, personal communication).



# HENRY MOUNTAINS

Table 3.

1987

Granite Creek  
5-20 10-4

Pistol Creek  
6-11 8-26 9-24

## Physical Measurements\*

Field pH	8.0	7.0	8.7	8.5	8.5
Lab pH	7.9	7.2	7.9	8.2	7.4
Field Cond. (umhos/cm)	188.0	324.0		320.0	220.0
Lab Cond. (umhos/cm)	190.0	250.0	225.0	320.0	250.0
Field Temp. (°C)		5.2	11.0	10.0	9.0
Field DO (ppm)		8.1	8.0	8.0	8.0
Flow (CFS)		.1	.2	.2	.2

## Laboratory Results\*

ANC (ueq/l)	1600.0	2660.0	2400.0	2880.0	2320.0
Total Alk.	80.0	133.0	120.0	144.0	116.0
TSS	17.0	.1	12.5	5.0	6.0
TDS	112.0	178.0	121.0	202.0	178.0
SO <sub>4</sub>	14.0	22.0	22.6	42.0	23.4
Cl	1.0	1.6	1.6	2.0	1.0
Hardness	89.7	148.0	94.0	154.0	117.0
CO <sub>3</sub>	0.0	.5	1.0	3.4	.5
HCO <sub>3</sub>	98.0	133.0	116.0	137.0	115.0
CO <sub>2</sub>	1.0	31.0	3.0	.7	.8
OH	0.0	.5	.5	.5	.5
Na	2.0	4.0	4.8	6.27	5.0
K	1.0	.8	.5	.65	.7
Ca	31.0	53.0	36.2	50.6	41.0
Mg	3.0	4.0	4.5	6.2	5.3
Cu	.01	.01	.01	.01	.01
Fe	.03	.08	.01	.17	.08
Al	.01	.10	.10	.10	.10
Mn	.005	.01	.01	.01	.01
Pb		.005	.005	.005	.004
Zn	.01	.01	.01	.02	.01
As		.008	.004	.004	.004
Se	.004	.004	.004	.004	.004
Ag		.01	.01	.01	.01
Cd		.006	.005	.005	.005
Ba	.016	.02	.01	.01	.01
Ni		.01	.01	.02	.02
Cr		.01		.01	.01
Hg				.0001	.0001
TOC		1.5		2.3	4.7
NH <sub>3</sub>		.05	.05	.05	.49
NO <sub>2</sub>	.01	.02	.02	.02	.02
NO <sub>3</sub>	.04	.20	.07	.2	.02
PO <sub>4</sub>		.02	.02	.02	.07
TP	.02	.10	.10	.10	.10



# HENRY MOUNTAINS

Table 3. (continued)

1987	<u>South Ck. Slate Ck. Straight Ck.</u>			<u>Crescent Ck.</u>	
	8/18	8/20	7/23	5/20	10/4
<u>Physical Measurements*</u>					
Field pH	8.6	8.7	8.7	8.5	7.1
Lab pH	8.3	8.1	8.0	7.6	6.9
Field Cond. (umhos/cm)	30.0	25.0	20.0	167.0	274.0
Lab Cond. (umhos/cm)	305.0	300.0	205.0	168.0	300.0
Field Temp.	17.0	8.0	12.0		3.8
Field DO (ppm)	8.0	9.0			9.4
Flow (CFS)	.03	.08	.4		.1
<u>Laboratory Results*</u>					
ANC (ueq/l)	2600.0	3080.0	1640.0	720.0	1272.0
Total Alk.	130.0	154.0	82.0	36.0	63.6
TSS	52.9	.5	2.1	67.0	6.1
TDS	204.0	184.0	127.0	142.0	191.0
SO <sub>4</sub>	49.8	42.3	21.2	39.0	71.8
Cl	1.0	1.0	1.0	.10	1.5
Hardness	160.0	146.0	93.0	68.1	119.0
CO <sub>3</sub>	2.1	5.2	3.6	0.0	.5
HCO <sub>3</sub>	120.0	145.0	80.0	44.0	64.0
CO <sub>2</sub>	1.8	.7	.2	1.0	14.0
OH	.5	.5	.5	0.0	.5
Na	4.1	4.1	3.0	3.0	6.0
K	1.3	.7	.4	1.0	.9
Ca	58.3	51.1	33.4	24.0	45.0
Mg	4.1	4.1	3.1	2.0	3.3
Cu	.05	.09	.01	.06	.01
Fe	1.11	.12	.12	.69	.30
Al	1.1	.1	.1	.65	.10
Mn	.02	.01	.01	.04	.02
Pb	.014	.13	.004		.005
Zn	.04	.03	.01	.01	.01
As	.17	.03	.004		.004
Se	.006	.012	.004		.004
Ag	.01	.01	.01		.01
Cd	.005	.005	.01		.005
Ba	.005	.005	.04	.01	.01
Ni	.01	.01	.01		.01
Cr	.01	.01	.01		.01
Hg	.0001	.0001	.0001		
TOC	26.0	2.2	26.0		1.0
NH <sub>3</sub>	.21	.05	.13		.05
NO <sub>2</sub>	.02	.02	.02	.01	.02
NO <sub>3</sub>	.02	.05	.02	.26	.58
PO <sub>4</sub>	.02	.02	.02		.02
TP	.1	.1	.10	.05	.10

\* MG/L except ANC

## La Sal Mountains

### Site Descriptions

Three streams, all of which are headwater streams, were sampled by the Utah Bureau of Water Pollution Control. Samples were surface grabs according to standards sampling procedures,

Mill Creek, a west slope stream originating near 10,400 ft. elevation, was sampled at its 9,000 ft. elevation in T. 26S., R. 24E., Sec. 33; flows are perennial, but vary according to climatic condition.

Geyser and La Sal Creeks are east slope streams originating above 10,400 ft. elevation. Geyser Creek was sampled near the 10,000 ft. elevation in T. 27S., R. 24E., Sec. 1. La Sal Creek was also sampled near its 10,000 ft. elevation which is located in T. 27S., R. 24E., Sec. 26. Both are perennial streams whose flows are influenced by climatic conditions.

### Water Chemistry

La Sal and Mill Creeks were sampled 5-27-87 and 10-7-87 while Geyser Creek was sampled only on 10-7-87. Physical parameters indicate that these waters have above neutral pH's (from 7.2 to 8.8), low conductivities (from 50 umhos/cm to 175 umhos/cm), and high dissolved oxygen content (from 7.0 to 11.5 ppm). All streams were high headwater streams above 10,000 ft. with low flows (.03-6.5 cfs). Laboratory results indicate the acid neutralizing capacities (ANC) of all of the creeks were above the 200 ueq/l level with values ranging from 660 ueq/l to 1340 ueq/l. Bicarbonates were moderate with readings ranging from 32 mg/l - 82 mg/l. Other anions were moderate. The major base cations, Ca and Mg, were moderate reading: Ca 7.0 - 26.0 mg/l and Mg 1.0 - 5.0 mg/l. All other anions and cations values were moderate, most at or above MDL. Nitrogen and phosphorus values were minimal or at MDL. The chemistry data indicate that all creeks were not sensitive to acid deposition (Table 4) having ANC's ranging from 660 ueq/l to 1340 ueq/l. This area is predicted to be a Type II terrain having low to moderate buffering capacities. A discussion of poor correlation between water ANC and predicted bedrock ANC can be found at the end of this paper.

### Fisheries

Mill Creek's sample was taken from Section Number 5 of this stream. This section support's populations of cutthroat, brook rainbow (Salmo gairdneria) and brown trout (Salmo trutta). Rainbow trout is stocked, the others are self-sustaining. This stream is rated a Class 3 fishery with unique qualities. It was last surveyed in August, 1987.

Geyser Creek supports populations of naturally reproducing cutthroat trout. It is rated a Class 3B, with both spawning and rearing habitat and was last surveyed in 1972.

La Sal Creek, in Section 3 which runs from the diversion below Medicine Lake road crossing upstream, supports a naturally-reproducing cutthroat trout population. It is rated Class 3B fishery and was surveyed August, 1984.

# LA SAL MOUNTAINS

Table 4.

1987	<u>Geyser Creek</u> 10/7	<u>Mill Creek</u> 5/27 10/7		<u>La Sal Creek</u> 5/27 10/7	
<u>Physical Measurements*</u>					
Field pH	8.3	8.8	8.2	8.8	8.3
Lab pH	7.2	8.0	7.7	7.4	6.7
Field Cond. (umhos/cm)	90.0	160.0	155.0	65.0	80.0
Lab Cond. (umhos/cm)	90.0	150.0	175.0	50.0	85.0
Field Temp. (°C)	8.2		5.4		4.1
Field O <sub>2</sub> (ppm)	8.9		11.5		7.0
Flow (CFS)	.3		6.5		.03
<u>Laboratory Results*</u>					
ANC (ueq/l)	1000.0	1340.0	1200.0	740.0	660.0
Total Alk.	50.0	67.0	60.0	37.0	33.0
TSS	.4	3.0	.40	3.0	.1
TDS	66.0	98.0	103.0	34.0	60.0
SO <sub>4</sub>	7.2	12.0	14.0	2.0	5.4
Cl	1.0	1.0	1.0	1.0	1.0
Hardness	31.2	75.5	73.8	21.6	32.7
CO <sub>3</sub>	.6	0.0	.5	0.0	.5
HCO <sub>3</sub>	48.0	82.0	59.0	46.0	32.0
CO <sub>2</sub>	.5	1.0	1.0	2.0	.4
OH <sup>-</sup>	.5	0.0	.5	0.0	.5
Na	3.0	2.0	2.0	1.0	2.0
K	.5	1.0	.8	1.0	.5
Ca	12.9	22.0	26.0	7.0	14.0
Mg	2.7	5.0	4.6	1.0	1.1
Cu	.01	.02	.01	.02	.01
Fe	.07	.02	.08	.07	.06
Al	.1	.2	.1	.2	.1
Mn	.02	.005	.02	.02	.02
Pb	.005		.005		.005
Zn	.01	.01	.01	.01	.01
As	.004		.004		.004
Se	.004		.004		.004
Ag	.01		.01		.01
Cd	.005		.005		.005
Ba	.03	.064	.08	.02	.03
Ni	.01		.01		.01
Cr	.01		.01		.01
TOC	1.5		.31		.2
NH <sub>3</sub>	.06		.05		.05
NO <sub>2</sub>	.02	.01	.02	.01	.02
NO <sub>3</sub>	.2	.24	.22	.1	.2
PO <sub>4</sub>	.02		.02		.02
TP	.1	.07	.1	.02	.1

\*MG/L except ANC

## RAFT RIVER

### Site Descriptions

The four streams which were sampled, Clear, George, Johnson, and One Mile, originate on the north slope of the Raft River Mountain at elevations near 9,000 ft. They are all characterized by having minimal flow rates. The upper reaches of these streams may not be perennial due to climatic conditions. Most are diverted for irrigation at lower elevations. The sites were at the U.S. Forest Service boundary in the following locations: Clear Creek was sampled in T. 14N., R. 13W., Sec. 10; One Mile Creek in T. 15N., R. 14W., Sec. 3; George Creek in T. 14N., R. 14W., Sec. 20; and Johnson Creek in T. 14N., R. 15W., Sec. 21. All four streams were sampled at lower elevations (approximately 6,500 ft.) than was anticipated. Future sites must be at higher elevations--preferably above 9,000 ft.

These samples were collected by staff members from the Division of Wildlife Resources and Reid Ellis, a volunteer Boy Scout (See Appendix for Reid Ellis's Eagle Scout Project Report based on this sampling project).

### Water Chemistry

All four streams were sampled the week of 9-30-87. Physical parameters indicated waters with a pH slightly above neutral (from 7.2 - 8.2), and low to moderate conductivities (170 - 600 umhos/cm). Laboratory results indicate the acid neutralizing capacity (ANC) of all creeks at these lower elevations ranged from 1200 ueq/l - 3520 ueq/l. Bicarbonates were very low with readings of 6 mg/l and 10 mg/l. Other anions were moderate. The major base cations, Ca and Mg, are moderate to high: Ca ranging from 17-66 mg/l and Mg 3.6 to 87 mg/l. All other anions and cations values were low or at MDL. Nitrogen and phosphorus values were somewhat high, either at or above recommended levels.

The chemistry data indicate that all four streams were not sensitive to acid deposition (Table 5) at the sample sites. The chemistry of the higher elevations is not known and further sampling should be initiated in 1988. Bedrock ANC indicates that portions of the Raft River Range are Type 4 terrain having very high buffering capacities. This correlates well with the low elevation data but high elevation water ANC's are unknown.

### Fisheries

The Johnson Creek sample was taken from Section 2, which extends from the U.S. Forest Service boundary to the headwaters. It was last surveyed in 1973 and at that time supported cutthroat and brook trout populations. It is not stocked and is a Class 3 fishery.

One Mile Creek makes up one stream section in its entirety. It is rated a Class 3 fishery and was last surveyed in 1976. A naturally-reproducing cutthroat trout was found in One Mile Creek at that time.

Section 2 of Clear Creek was sampled. This section extends from a diversion to the headwaters. Clear Creek was last surveyed in 1973 when it was found to support rainbow, cutthroat, brown and brook trout populations; it is not stocked.



# RAFT RIVER MOUNTAINS

Table 5.

1987	<u>Clear Ck.</u> 9/30	<u>One Mile Ck.</u> 9/30	<u>Johnson Ck.</u> 9/30	<u>George Ck.</u> 9/26
<u>Physical Measurements*</u>				
Field pH				
Lab pH				
Field Cond. (umhos/cm)	7.6	8.2	8.0	7.5
Lab Cond. (umhos/cm)	17.0	400.0	500.0	600.0
Field Temp. (°C)				9.4
Field DO (ppm)				
<u>Laboratory Results*</u>				
ANC (ueq/l)	1200.0	2860.0	3420.0	3520.0
Total Alk.	60.0	143.0	171.0	176.0
TSS	14.9	25.0	1.3	3.6
TDS	105.0	230.0	282.0	366.0
SO <sub>4</sub>	13.3	16.6	27.6	20.5
Cl	13.0	33.0	47.0	53.0
Hardness	55.1	127.0	175.0	167.0
CO <sub>3</sub>	.5	.5	.5	.5
HCO <sub>3</sub>	58.0	14.0	168.0	168.0
CO <sub>2</sub>	2.4	1.5	3.2	11.0
OH	.05	.05	.05	.05
Na	15.0	35.0	34.0	45.0
K	1.4	2.4	2.3	1.8
Ca	17.0	41.0	60.0	66.0
Mg	3.6	8.0	8.7	12.0
Cu	.01	.01	.01	.01
Fe	.39	.27	.08	.01
Al	.1	.1	.1	.1
Mn	.01	.01	.01	.01
Pb	.005	.005	.005	.005
Zn	.01	.01	.01	.01
As	.004	.017	.004	.004
Se	.004	.008	.004	.004
Ag	.01	.01	.01	.01
Cd	.005	.005	.005	.005
Ba	.02	.04	.03	.02
Ni	.01	.02	.01	.04
Cr	.01	.02	.02	.01
Hg	.0001	.0001	.0001	
TOC	1.43	1.93	1.01	2.1
NH <sub>3</sub>	.1	.1	.05	.05
NO <sub>2</sub>	.02	.02	.02	.02
NO <sub>3</sub>	.02	.13	.15	.51
PO <sub>4</sub>	.05	.02	.02	.04
TP	.1	.1	.1	.1

\*MG/L except ANC

## UINTA MOUNTAINS

### Site Description

Walk-Up and Figure 8 Lakes are located in the White Rocks River drainage at elevations of 11,100 ft. and 10,650 ft., respectively. The sampling location for Walk-Up Lake was in T. 5N., R. 1W., Sec. 19, and for Figure 8 Lake was in T. 5N., R. 1W., Sec. 29. Both are cirque lakes with no inflows from perennial streams. Lake water is from snow melt or groundwater. No apparent surface discharge exists on either lake. Samples were surface grabs near shore and collected by Division of Wildlife Resource personnel.

Heart and Dean Lakes are located on the West Fork of Rock Creek at elevations of 10,500 ft. and 10,750 ft., respectively. Heart Lake was sampled in T. 2N., R. 8W., Sec. 5, and Dean Lake in T. 3N., R. 8W., Sec. 2. Both lakes lie at the base of steep talus slopes with no apparent surface perennial inflow streams. Lake water is from snow melt or ground water. Samples were surface grabs near shore.

### Water Chemistry

All four lakes were sampled during the week of 10-5-87 to 10-12-87. Physical parameters indicated waters with a pH below neutral or slightly above (from 6.0 to 8.3), and low conductivities (between 9 and 15 umhos/cm). Laboratory results indicate the acid neutralizing capacity (ANC) of all four lakes was  $\leq 200$  ueq/l. Bicarbonates were very low with readings of 10.0 mg/l. Other anions were also very low. The major base cations, Ca and Mg, were low reading: Ca 1.0-2.0 mg/l and Mg .2 to 1.7 mg/l. All other anions and cations values were very low, or at MDL. Nitrogen and phosphorus values were minimal or at MDL. The chemistry data indicate that all four lakes were sensitive to acid deposition having ANC's of less than 200 ueq/l at the time of sampling (Table 6). The water ANC values correlate well with the bedrock ANC prediction that the Uinta Mountains are a Type 1 terrain have no buffering capacity.

### Fisheries

Walk-Up Lake supports both brook and cutthroat trout populations. It is a stocked fishery. The fishery classification system for the waters of Utah does not adequately evaluate the high mountain lakes and so the Uinta Mountain lakes are considered to be unique. It was last surveyed in 1976 (Shipley and Crosby, 1976).

Figure 8 Lake supports a naturally-reproducing cutthroat trout population. It was surveyed in 1976 (Shipley and Crosby 1976).

Dean Lake supports a stocked brook trout fishery. It was surveyed in August, 1983 (Larson, E.W., 1983).

The Heart Lake cutthroat fishery is maintained by a 2 year stocking cycle. This lake was surveyed in 1983 (Larson, E.W., 1983).

# UINTA MOUNTAINS

Table 6.

1987	Dean LK. 10/9	Heart LK. 10/12	Walk-Up 10/5	Figure 8 10/5
<u>Physical Measurements*</u>				
Field pH	7.7	6.7		
Lab pH	7.0	6.4	6.2	6.0
Field Cond. (umhos/cm)		10.0	6.2	6.0
Lab Cond. (umhos/cm)	12.0	9.0	12.0	15.0
Field Temp. (°C)	6.1	8.3	12.0	15.0
<u>Laboratory Results*</u>				
ANC (ueq/l)	≤200.0	≤200.0	≤200.0	≤200.0
Total Alk.	10.0	10.0	10.0	10.0
TSS	0.0	1.6	1.6	4.1
TDS	11.0	13.0	28.0	31.0
SO <sub>4</sub>	5.3	5.0	7.3	7.5
Cl	1.0	1.0	1.0	1.0
Hardness	10.0	10.0	10.0	10.0
CO <sub>3</sub>	.5	.5	.5	.5
HCO <sub>3</sub>	2.0	.2	10.0	10.0
CO <sub>2</sub>	.1	.2	10.0	10.0
OH	.5	.5	.5	.5
Na	1.0	1.0	1.0	1.0
K	.3	.2	.4	.4
Ca	1.0	2.1	1.1	1.3
Mg	1.7	.5	.2	.3
Cu	.03	.05	.01	.01
Fe	.2	.06	.08	.12
Al	.7	.1	.1	.1
Mn	.07	.03	.01	.01
Pb	.005	.005	.006	.005
Zn	.01	.01	.01	.01
As	.004	.006	.004	.004
Se	.008	.004	.004	.004
Ag	.01	.01	.01	.01
Cd	.005	.005	.005	.005
Ba	.03	.01	.03	.03
Ni	.01	.01	.01	.04
Cr	.01	.02	.01	.01
TOC	3.40	2.21	.47	1.3
NH <sub>3</sub>	.05	.46	.05	.05
NO <sub>2</sub>	.02	.02	.02	.02
NO <sub>3</sub>	.2	.2	.2	.2
PO <sub>4</sub>	.02	.02	.02	.02
TP	.1	.1	.1	.1

\*MG/L except ANC



## WASATCH MOUNTAINS

### Site Description

Pittsburgh Lake is a high elevation lake situated at 9,400 ft. on a south facing slope of American Fork Canyon. The lake has no outlet or inflow streams. Lake water is from surface runoff or ground water. The coordinates are Lat. 40° 33' 30". Long. 113° 36' 57". The lake was sampled by Logan and Lamont Jubeck, volunteer Boy Scouts (see appendix for their Eagle Scout Reports on this sampling project), who had been trained by Division of Environmental Health personnel to take the water samples according to standard sampling procedures. The samples were surface grabs near shore.

Lake Hardy is a high elevation lake situated at 9,900 ft. It is also located on a south facing slope of American Fork Canyon. The lake has no significant inlet streams. Lake water is from surface runoff or groundwater. Surface grab samples were taken from an outlet which drains to American Fork Canyon in T. 3S., R. 2E., Sec. 28. This lake was also sampled by volunteer Boy Scouts.

### Water Chemistry

Pittsburgh and Hardy Lakes were sampled the weeks of 8-29-87 and 10-8-87. Lake Hardy was also sampled on 7-18-87. Physical parameters indicated waters with a pH below neutral or slightly above (from 6.5 to 7.3), low conductivities (between 16 and 33 umhos/cm), and dissolved oxygen (5.2 to 8.6 ppm). Both lakes are high headwater lakes above 10,000 ft. Laboratory results indicate the acid neutralizing capacity (ANC) of Pittsburgh Lake on 8-25-87 was  $\leq 200$  ueq/l, and 680 ueq/l on 10-8-87. Bicarbonates were very low with readings of 10 mg/l and 14 mg/l. The ANC value of Lake Hardy was  $\leq 200$  ueq/l on 7-18-87, and 800 ueq/l on 8-29-87 and 2060 ueq/l on 10-9-87. Bicarbonates values were 3 mg/l, 10 mg/l and 10 mg/l. Other anions on both lakes were also very low. The major base cations, Ca and Mg, were low reading: Ca 1.2-7.0 mg/l and Mg 3 - 4 mg/l. All other anions and cations values were very low or at MDL. Nitrogen and phosphorus values were minimal or at MDL.

The chemistry data indicates that both lakes are sensitive to acid deposition earlier in the year (July and August showing ANC values of less than 200 ueq/l), but become buffered in the late summer and the fall having ANC values ranging from 680 ueq/l to 2060 ueq/l (Table 7). This may be the result of longer retention and contact times with the substrate. Lake Hardy is situated on glacial material which is underlain by quartz monzonite. The bedrock ANC for this geologic setting, a Type 5 terrain, cannot be predicted without a thorough geologic study. The ANC for the Pittsburgh Lake area was not indicated in the previous paper.

### Fisheries

Pittsburgh Lake supports a stocked brook trout population, with some possible natural reproduction. It is rated a Class 3 fishery and was last surveyed in 1974.

Lake Hardy was last surveyed in August, 1982, at which time no fish were observed. It was last stocked with 1,000 brook trout fingerling in 1973.

# WASTACH MOUNTAINS

Table 7.

1987	<u>Pittsburgh Lake</u>		<u>Lake Hardy</u>		
	8/25	10/8	7/18	8/29	10/9
<u>Physical Measurements*</u>					
Field pH	7.1	7.1	6.7	7.3	6.7
Lab pH	7.3	7.1	6.5	6.7	7.2
Field Cond. (umhos/cm)					
Lab Cond. (umhos/cm)	33.0	25.0	27.0	16.5	18.0
Field Temp. (°C)	13.4	12.2	13.3	15.0	14.4
Field DO (ppm)	8.6	4.8	6.0	8.4	5.2
<u>Laboratory Results*</u>					
ANC (ueq/l)	≤200.0	680.0	≤200.0	800.0	2060.0
Total Alk.	10.0	34.0	10.0	10.0	103.0
TSS	1.9	2.3	.9	5.3	3.9
TDS	20.0	22.0	10.0	11.0	14.0
SO <sub>4</sub>	5.0	5.0	5.0	5.0	5.0
Cl	1.0	2.4	2.3	1.0	1.7
Hardness	13.0	34.0	14.0	10.0	68.0
CO <sub>3</sub>	.5	.5	.5	.5	.5
HCO <sub>3</sub>	10.0	14.0	3.0	10.0	10.0
CO <sub>2</sub>	1.0	2.5	3.0	1.0	.05
OH	.5	.5	.5	.5	.5
Na	2.2	1.0	.5	.4	1.0
K	.8	.5	.3	.3	.4
Ca	7.0	2.8	1.2	1.7	1.6
Mg	1.1	.6	.3	.3	.3
Cu	.07	.01	.01	.01	.01
Fe	.3	.22	.12	.72	.7
Al	.1	.1	.1	.1	.1
Mn	.01	.02	.01	.03	.03
Pb	.008	.006	.005	.008	.005
Zn	.04	.01	.02	.02	.01
As	.05	.005	.004	.004	.006
Se	.004	.004	.004	.004	.004
Ag	.01	.01	.01	.01	.01
Cd	.005	.005	.004	.005	.005
Ba	.07	.05	.10	.04	.01
Ni	.01	.01	.01	.02	.01
Cr	.01	.01	.01	.05	.01
Hg	.0001		.0005	.0001	
TOC	19.0	2.8	3.6	2.3	3.7
NH <sub>3</sub>	.05	.05	.05	.05	.05
NO <sub>2</sub>	.02	.02	.02	.02	.02
NO <sub>3</sub>	.02	.02	.02	.02	.02
PO <sub>4</sub>	.02	.02	.02	.02	.02
TP	.1	.1	.1	.1	.1

\*MG/L except ANC



## TUSHAR MOUNTAINS

### Site Descriptions

Beaver and Poison Creeks are high headwater (above 10,000') flow (.5 - 3.8 cfs) streams originating in the Tushar Mountains. Beaver Creek begins in the Big Meadow near 10,700 ft. in elevation and flows easterly to the Sevier River. The sample point is near the 10,000 ft. elevation in T. 27S., R. 5W., Sec. 35. Poison Creek originates below Delano Peak at 11,500 ft. in elevation and flows southwesterly to the Beaver River. Its sample was taken at 10,000 ft. in T. 28S., R. 5W., Sec. 14; both are perennial streams.

Surface grab samples were taken by Utah Bureau of Water Pollution Control personnel and procedures were according to standard sampling procedures.

### Water Chemistry

Both creeks were sampled 6-23-87 and 10-15-87. Physical parameters indicated waters with a pH slightly below or above neutral (from 6.0 to 8.0), low conductivities (40 and 120 umhos/cm), and high dissolved oxygen content (8.2 ppm). Laboratory results indicate the acid neutralizing capacity (ANC) of Beaver Creek was  $\leq 200$  ueq/l on both sampling occasions. Bicarbonates were very low with readings of 6 mg/l and 10 mg/l. The ANC values of Poison Creek were 600 and 1200 ueq/l. Bicarbonates values were 40 mg/l and 60 mg/l. Other anions on both streams were also very low. The major base cations, Ca and Mg, were low reading: Ca 2.0-17.0 mg/l and Mg .1 - 31 mg/l. All other anions and cations values were very low, most at or below MDL. Nitrogen and phosphorus values were minimal or at MDL. The chemistry data indicates that Beaver Creek, having an ANC of less than 200 ueq/l, is sensitive to acid deposition, while Poison Creek, showing ANC values of 600 and 1200 ueq/l, is not (Table 8). The Tushar Mountains are predicted to be a Type 2 terrain, having low to moderate buffering capacity. A discussion of poor correlation between water ANC and predicted bedrock ANC can be found at the end of this paper.

### Fisheries

Poison Creek has not been surveyed as to its fishery value.

Beaver Creek, from the diversion pond near Marysville, upstream to the headwaters makes up Section 2, from which the sample was taken. It is a Class 3B fishery, supporting a naturally-reproducing rainbow trout population. This fishery is also supplemental with stocked catchables. Beaver Creek was last surveyed in 1981.

# TUSHAR MOUNTAINS

Table 8.

1987

Beaver Creek  
6/23 10/15

Poison Creek  
6/24 10/15

## Physical Measurements\*

Field pH	2.5	6.7	2.8	
Lab pH	6.9	6.0	8.0	7.3
Field Cond. (umhos/cm)	62.0	111.0	90.0	
Lab Cond. (umhos/cm)	40.0	80.0	105.0	120.0
Field Temp. (°C)	4.4	1.2	5.4	
Field DO (ppm)	8.2	8.2	8.2	
Flow (CFS)	1.7	.5	3.8	

## Laboratory Results\*

ANC (ueq/l)	≤ 200.0	≤ 200.0	740.0	1200.0
Total Alk.	10.0	10.0	37.0	59.9
TSS	1.6	5.0	.6	3.7
TDS	16.0	79.0	46.0	88.0
SO <sub>4</sub>	5.0	30.4	5.0	8.5
Cl	1.0	1.0	1.0	1.8
Hardness	10.0	16.8	30.0	38.6
CO <sub>3</sub>	2.8	.5	.5	.5
HCO <sub>3</sub>	6.0	10.0	40.0	60.0
CO <sub>2</sub>	.1	8.0	.6	4.5
OH	.5	.5	.5	.5
Na	3.0	5.0	2.2	4.0
K	.5	.7	.2	.4
Ca	2.0	8.2	11.3	17.0
Mg	.1	.9	2.2	3.1
Cu	.01	.01	.01	.01
Fe	.02	.35	.1	.09
Al	.10	1.1	.4	.1
Mn	.01	.08	.01	.01
Pb	.005	.005	.005	.005
Zn	.02	.01	.02	.01
As	.004	.005	.004	.004
Se	.004	.004	.004	.004
Ag	.01	.01	.01	.01
Cd	.005	.005	.005	.005
Ba	.01	.01	.01	.01
Ni	.01	.01	.01	.01
Cr	.01	.01	.01	.01
TOC		1.2		1.3
NH <sub>3</sub>	.05	.07	.05	.05
NO <sub>2</sub>	.02	.02	.02	.02
NO <sub>3</sub>	.19	.3	.09	.2
PO <sub>4</sub>	.02	.02	.02	.02
TP	.1	.1	.1	.1

\*MG/L except ANC

## THOUSAND LAKE MOUNTAINS

### Site Description

Deep and Snow Lakes are both located in T. 27S., R. 4E., Sec. 27 below the east rim of Thousand Lake Mountain at an elevation of approximately 10,515 ft. The lakes receive water from snow melt or groundwater, since neither has a significant inflow stream. Snow lake is an enclosed system with no outlet, while Deep Creek lake has an outlet which drains to the northeast. The samples on Deep Creek Lake were surface grabs near the outlet while the samples on Snow Lake were surface grabs taken near the shore. Both sets were collected by staff members of the Utah Bureau of Water Pollution Control.

### Water Chemistry

Both sites were sampled on 8-6-87 and again on 10-15-87. Physical parameters of the lakes indicated waters with a pH slightly above or below neutral (from 6.7 to 7.3), low conductivities (from 29 to 142 umhos/cm), and dissolved oxygen (7.0 and 8.4 ppm). Laboratory results indicate that these two lakes, although a short distance apart, had different water chemistries and ANC. Snow Lake had an ANC value of less than 200 ueq/l on both sampling occasions. Bicarbonates were 40 mg/l and 10 mg/l. The major base cations, Ca and Mg, were also low reading: Ca 2.7 and 2.6 mg/l, and Mg 1.1 and 1.0 mg/l. Other anions and cations were low, most near or below MDL.

The ANC values measured for Deep Creek Lake were substantially greater at 1560 ueq/l and 680 ueq/l, and thus the lake is not sensitive to acid deposition. Bicarbonates were 50 mg/l and 34 mg/l. Other anions and cations were higher than at Snow Lake. The major base cations, Ca and Mg, showed moderate values: Ca 5.2 and 5.9 mg/l and Mg 2.1 and 2.2. The chemistry data indicate that the two lakes have significantly different ANC; Snow Lake being sensitive to acid deposition, while Deep Creek Lake is not (Table 9). Both lakes are located on quaternary glacial alluvium - Type 5 terrain, the bedrock ANC, of which cannot be predicted without a thorough geologic study of the area.

### Fisheries

Deep Creek Lake supports a stocked, brook trout fishery. It is rated a Class 3 fishery and was last surveyed in 1972.

Snow Lake has not been surveyed as to its fishery potential.

# THOUSAND LAKE MOUNTAINS

Table 9.

1987	<u>Snow Lake</u>		<u>Deep Ck Lake</u>	
	8/6	10/15	8/6	10/15
<u>Physical Measurements*</u>				
Field pH		8.2		
Lab pH	6.7	6.7	7.3	7.0
Field Cond. (umhos/cm)	40.0	57.0	59.0	
Lab Cond. (umhos/cm)	29.0	30.0	55.0	50.0
Field Temp. (°C)		3.0		
Field O <sub>2</sub> (ppm)		7.0		
<u>Laboratory Results*</u>				
ANC (ueq/l)	≤ 200.0	≤ 200.0	1560.0	680.0
Total Alk.	10.0	10.0	78.0	34.0
TSS	14.2	21.5	1.5	3.7
TDS	49.0	53.0	54.0	56.0
SO <sub>4</sub>	5.0	7.6	5.0	5.0
Cl	1.0	1.0	1.0	1.0
Hardness	13.0	12.8	20.0	20.1
CO <sub>3</sub>	.5	.5	.5	.5
HCO <sub>3</sub>	40.0	10.0	50.0	34.0
CO <sub>2</sub>	14.0	.1	14.0	11.0
OH	.5	.5	.5	.5
Na	1.1	1.0	2.1	2.0
K	1.7	1.7	1.1	1.4
Ca	2.7	2.6	5.7	5.9
Mg	1.1	1.2	2.1	2.2
Cu	.02	.01	.02	.01
Fe	.90	.79	.03	.06
Al	1.60	1.20	.10	.10
Mn	.01	.02	.01	.01
Pb	.004	.005	.004	.005
Zn	.02	.01	.01	.01
As	.004	.005	.004	.005
Se	.004	.004	.004	.004
Ag	.01	.01	.01	.01
Cd	.01	.01	.01	.01
Ba	.02	.02	.01	.01
Ni	.01	.01	.01	.01
Cr	.01	.01	.01	.01
Hg	.0001		.0001	
TOC	37.0	8.4	20.0	30.0
NH <sub>3</sub>	.07	.08	.05	.08
NO <sub>2</sub>	.02	.20	.02	.20
PO <sub>4</sub>	.03	.03	.02	.03
TP	.10	.10	.10	.10

\*MG/L except ANC

## PINE VALLEY MOUNTAINS

### Site Description

The Santa Clara River originates from streams draining the north slope of the Pine Valley Mountains at elevations above 9,000 ft. Many of its headwater streams may be intermittent due to climatic conditions.

Due to limited accessibility to high elevation terrain, the Santa Clara River was sampled at an elevation of approximately 7,200 ft. at the Pine Valley Recreation area at Lat. 37°27'33". Long. 113°27'09'. The sample, taken by a member of the Bureau of Water Pollution Control, was a surface grab according to standard sampling procedures. An effort will be made to sample the left fork, middle fork and further water in the summer and fall of 1988.

### Water Chemistry

Water samples taken on August 4, 1987 indicate an ANC value of 1,020 ueq/l, a pH of 8, a conductivity of 115 umhos/cm, and a bicarbonate level of 44 mg/l. Other anions were at MDL or above. The major base cations, Ca and Mg were moderate at 11.9 mg/l and 5.1 mg/l respectively. Other anions and cations were also of moderate values. Nutrient values were quite low except a .05 mg/l reading for ortho phosphorus.

The chemistry data indicate the system is not sensitive to acid deposition (Table 10) at the 7,200 ft. elevation, but the ANC at higher elevations is unknown at this time. Further sampling at elevations over 9,000 ft. is needed. The Pine Valley Mountains are considered to be Type 2 terrain having low to moderate buffering capacity.

### Fisheries

The section of the Santa Clara River from which samples were taken is Section 6, which extends from Pine Valley Reservoir to the headwaters. It was last surveyed in 1971 and supported naturally-reproducing populations of rainbow and brook trout. It is a Class 3 fishery.



# PINE VALLEY MOUNTAINS

Table 10.

1987

Santa Clara River  
8/4

## Physical Measurements\*

Field pH	8.0
Lab pH	7.8
Field Cond. (umhos/cm)	131.0
Lab Cond. (umhos/cm)	115.0
Field Temp (°C)	15.1
Field DO (ppm)	7.1
Flow (CFS)	3.3

## Laboratory Results\*

ANC (ueq/l)	1020.0
Total Alk.	51.0
TSS	3.1
TDS	94.0
SO <sub>4</sub>	5.0
CL	1.0
Hardness	45.0
CO <sub>3</sub>	.5
HCO <sub>3</sub>	44.0
CO <sub>2</sub>	1.3
OH <sup>-</sup>	.5
Na	5.2
K	.5
Ca	11.9
Mg	5.1
Cu	.02
Fe	.20
Al	.10
Mn	.01
Pb	.004
Zn	.01
As	.006
Se	.004
Ag	.01
Cd	.01
Ba	.01
Ni	.01
Cr	.01
Hg	.0001
TOC	10.50
NH <sub>3</sub>	.05
NO <sub>2</sub>	.02
NO <sub>3</sub>	.02
PO <sub>4</sub>	.05
TP	.10

\*MG/L except ANC

### Summary

The table on the following page compiles the acid neutralizing capacity values determined from the water samples taken during 1987. Also included on this chart are the terrain sensitivity classes types for the sampling locations as predicted by Loren Morton's paper (see page 21 for a description of the terrain class types). The last column of the table indicates whether or not the water quality data matches the sensitivity of the areas as predicted by its bedrock geology.

Lack of correlation between the two ANC values, i.e. that measured for water and that predicted by the bedrock, can result from:

1. The deposition of air-borne carbonate dust which would increase the ANC of the water sample.
2. Groundwater influx from areas outside the drainage basins which would alter the ANC of the waters.
3. Higher ANC's of volcanic rocks than previously predicted.
4. The possibility that even very small amounts of carbonate material contained in the rocks could substantially alter the ground water chemistry and provide greater ANC than previously concluded.
5. Variable feldspar contents in the quartzites of Type 1 terrains.

### Recommendations

1. Detailed hydrogeologic studies must be completed in order to fully understand the effects of local stratigraphy and ground water/surface water flow systems on the ANC of a particular basin.
2. The lake and stream sampling program should be continued in areas that have been determined to be sensitive or marginally sensitive by ADTAC in order to establish baseline data for trend analysis.

Literature Cited

EPA, Western Lake Survey Phase I - Characteristics of Lakes in the Western United States: Volume I., 1987, p. 59.

EPA, Quality Criteria for Water, 1976.

Larson, E.W., High Uinta Lakes Survey - 1982. Rock Creek Drainage. Third Phase Survey. Utah Division of Wildlife Resources, 1983, p. 520.

Shipley, S. and C. Crosby, High Uinta Lakes Survey - 1976, White Rocks Drainage. Utah Division of Wildlife Resources, 1976, p. 146.

## SNOW CORE SAMPLING PROGRAM, WINTER 1987-1988

A Joint Effort of the Utah Snow Survey Program of the  
Soil Conservation Service, the Utah Bureau of Air Quality,  
and the Utah State Health Lab

December 16, 1987

### INTRODUCTION:

In order to determine the existence of acid deposition in sensitive areas in Utah it is necessary to assess the acid loading rates in these areas. One method of accomplishing this task is by collecting snow core samples and analyzing them for their soluble chemical constituents. The Utah Snow Survey Program of the Soil Conservation Service (SCS), which is responsible for estimating water reserves present in the snowpack, has agreed to collect snow core samples at six different locations in Utah for the Utah Bureau of Air Quality's Acid Deposition Sampling Program. Each location will be sampled four different times throughout the winter of 1987-1988. The chemical analyses of these samples will provide baseline data for the chemical content of the snowpack in the Uinta, Boulder, and Escalante Mountains.

### SNOW CORE SAMPLING LOCATIONS:

The following six locations were chosen because they are located in areas which have been classified as potentially "sensitive" to acid deposition. The four samples located in the Uinta Mountains are distributed across the range and will hopefully provide interesting data for comparison. In addition, the Lake Fork Mountain sample was chosen because of its proximity to the U.S.F.S. visibility monitor at Lake Fork.

1. Chepeta Lake: 40° 46' 110° 0'  
Sec. 4, T. 4N, R. 1W, Duchesne County  
Elevation: 10,300'
2. Lake Fork Mountain: 40° 36' 110° 26'  
Sec. 3, T. 2N, R. 5W, Duchesne County  
Elevation: 10,100'
3. Trial Lake: 40° 41' 110° 57'  
Sec. 5, T. 2S, R. 9E, Summit County  
Elevation: 9,960'
4. Steel Creek Park: 40° 55' 110° 30'  
Sec. 17, T. 2N, R. 13E, Summit County  
Elevation: 10,100'
5. Donkey Reservoir: 38° 13' 111° 28'  
Sec. 9, T. 30S, R. 4E, Wayne County  
Elevation: 9,800'

6. Widstoe #3                      37° 50' 111° 53'  
Sec. 22, T. 34S, R. 1W, Garfield County  
Elevation: 9,500'

**SAMPLING TOOL:** The standard 1.48" diameter aluminum Soil Conservation snow coring tool will be used to collect the sample.

**SAMPLING PROCEDURE:**

The snow survey crew will be provided pre-labeled 1 gallon polyethylene sample bottles and all other supplies necessary for the sampling program before leaving Salt Lake City for its sampling rounds at the end of each month.

At each designated location the snow survey crew, after completing its snow core transect to determine the amount of water present in the snowpack, will collect samples for the Bureau of Air Quality in the following manner:

1. Insert the snow coring tool, large or small diameter, depending on the depth of the snowpack, through the entire depth of the snow pack in order to obtain a complete snow column.
2. Remove the corer, now partially or completely filled with snow. Check the bottom of the corer to ensure that no dirt or glass is present at the bottom of the tool--if so remove that portion of the core that is contaminated. Before removing the large diameter coring device, insert a thin sheet of aluminum below the bottom and lift the two pieces together to minimize snow loss which may occur when extracting the corer. Check for contamination after lifting the tube.
3. Dislodge the contents of the tool into the provided 1 gallon wide-mouthed polyethylene container. If multiple cores are necessary to fill the container collect the additional cores as close to the first core as possible. Fill the container only with cores that represent the entire snowpack--do not use partial cores. See Table 1 for the approximate number of cores required to fill the sample container.
4. When the sample bottle is full or almost full, replace the cap and mark the date, how many cores it took to fill the sample bottle, which coring device was used--the large or small diameter corer, and the measured depth of the snowpack on the label. Continue on to the next sampling site.
5. Blank samples and split samples will be collected at various sites as indicated in the Quality Assurance Section.
6. Appropriate sample sampling handling forms will be prepared for each sample batch.



## QUALITY ASSURANCE (QA):

As part of the quality assurance plan for the snow sampling program it is necessary to collect blank and duplicate samples in the field. The procedure for this is as follows:

1. Two extra sample containers, one marked BLANK and one marked DUPLICATE, will be included in the batch of containers provided for the Uinta Mountain run. At one of the four stops during each sampling run, randomly select one of the extra sample containers. If the container is marked BLANK simply fill the container in the field with 1 liter of deionized water, which will be provided with the sample containers. Replace the cap on the sample container and mark the date and where the sample was taken on the label. If the container is marked DUPLICATE simply take a second sample as close to the first sample as possible at that location using the same procedure as outline in SAMPLE PROCEDURE.
2. The QA container that is left over from the Uinta run will then be filled when sampling at either of the southern sampling locations. The crew will randomly choose one of the locations and fill the leftover bottled marked either BLANK or DUPLICATE in the manner indicated above.
3. Split samples will be prepared in the lab.
4. A total of 9 samples will be analyzed for each complete sampling run.

## TRANSPORTATION OF SAMPLES:

After the samples are collected by the snow survey crew they will be transferred from the helicopter to a cooler carried by the helicopter support crew at the landing zone. At the completion of the run the cooler will then be transported via helicopter to the Salt Lake City Airport where the samples will be picked up by Carol Revelt or another member of the Utah State Department of Health for transportation to the Utah State Health Laboratory.

Arrangements for sample pick up in Salt Lake City will be made prior to each run to ensure proper handling.

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If you have any questions please contact:

Lindy Stankov, Bureau of Air Quality  
288 North 1460 West  
Salt Lake City, Utah 84118-0690  
Phone: 538-6108

\*\*\*\*\*

If any questions should arise regarding  
sampling protocol and I am unable to be  
reached, contact Bill Gabbert at  
(307) 733-2752. He has supervised snow  
sampling for the U.S.F.S. in the Bridger-  
Teton Forest.

\*\*\*\*\*

VI. APPENDIX





# State of Utah

## DEPARTMENT OF HEALTH

### DIVISION OF ENVIRONMENTAL HEALTH

Norman H. Bangerter  
Governor

Suzanne Dandoy, M.D., M.P.H.  
Executive Director

Kenneth L. Alkema  
Director

Bureau of Air Quality  
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#### MEMORANDUM

**TO:** ADTAC Members  
**FROM:** Mark T. Ellis, Coordinator  
**DATE:** February 10, 1987  
**SUBJECT:** ADTAC Meeting on January 9, 1987 and Results of Assignments

Our first meeting of 1987 introduced a new era for acid deposition work in Utah. The discussion which occurred follows:

ADTAC reported to the Utah Air Conservation Committee (UACC) on November 21, 1986 and the Utah Water Pollution Control Committee (UWPCC) on December 12, 1986. These committee reports were required by ADTAC's "charter". A third report was made to the Utah Wildlife Board on January 23, 1987. Since the wildlife agencies in the west have been active in the acid deposition issue, Maureen Wilson arranged for time before that body so that she and I could make a presentation. All three committees voted to accept ADTAC's recommendations encouraging the State to implement the recommendations for monitoring and for continuation of ADTAC as advisory body.

A sketch of a monitoring plan was submitted to the members for their comment. At this point in time, I have received no comments. The monitoring plan is designed to address a no-budget-base and the beginnings of a meaningful data base. Many groups have voiced support, in principle, for contributions to one or another portion of monitoring. I requested in the meeting that each person go back to their agency to see if it would be possible to gain a resource commitment to contribute to the monitoring plan. Resources may include man-or-women power, money, equipment, money, transportation, money, laboratory resources and analysis, and money. I would like to get your commitments as soon as possible. If it will help, I can meet with your agency to outline our needs in extra detail. We also need more exact locations to conduct the studies. If you have recommendations as a study site, please assist with this part of the logistics. Members not in attendance at the meeting will receive a copy of the monitoring plan with this memo.

The question of authority of ADTAC was discussed. This has as much to do with deciding a direction to go as it has from where we have come. If you will recall, Governor Bangerter requested the formation for this group, but it was the Department of Health which sponsored the organization of ADTAC. Ultimately, the Department of Health is our authority. We are required to assist both the Department and statutory committees in dealing with acid deposition. The question of the Governor's interest came up in the discussion. On January 22, 1987, I met with the Governor's staff on a related issue, but had the chance to ask about ADTAC's reception by the Governor's staff - copies of our report have been received and our visibility is increasing. Due to our efforts, we may be receiving assistance in achieving some of our goals from our congressional delegation. The degree to which we can expect support from the Governor is still not well defined, but our efforts have definitely awakened some awareness.







# State of Utah

## DEPARTMENT OF HEALTH DIVISION OF ENVIRONMENTAL HEALTH

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Governor

Suzanne Dandoy, M.D., M.P.H.  
Executive Director

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### MEMORANDUM

**TO:** ADTAC Members

**THROUGH:** F. Burnell Cordner, Director, Bureau of Air Quality

**FROM:** Mark T. Ellis, Environmental Health Scientist

**DATE:** May 8, 1987

**SUBJECT:** ADTAC Meeting, April 23, 1987

The Acid Deposition Technical Advisory Committee (ADTAC) met April 23, 1987 in the Cannon Health Building, according to the agenda as attached.

I presented data which had been mailed out earlier relative to the results of the Western Lake Survey (WLS). The acid neutralizing capacity (ANC) of the sampled lake waters in the most sensitive areas of the Uinta Mountains was consistently low. While Uinta lakes did not have the lowest ranges of ANC in the WLS, the standard deviation was so small (25.16 for Region 4DI) and the mean was so low that, as a group, these lakes must be considered to be extremely sensitive. The consistent nature of low ANC values would make the Uinta lakes an ideal area for further regional studies. The WLS also verified ADTAC's contention that the Boulder Mountain lakes are also sensitive.

Expansion of the scope of ADTAC to include technical/scientific representatives from industry and the environmental community was also discussed. The committee felt good that, providing that both groups were represented, these additions would be a benefit to the technical nature of ADTAC.

New members to ADTAC were introduced. These include Doyle Stephens, U.S. Geological Survey and Lynn Dudley, USU. Doyle explained his very broad background in water projects, including the WLS, the Salt Lake County Urban Run-off study and other surface water projects. Lynn has been involved as a soil scientist in the study of salinity, soil nutrients, and soil sensitivity to sulfuric acid. He showed slides which illustrated the two primary sensitive soil types in Utah, i.e., 1-Cryoboralfs which are most sensitive and have a very thin A-horizon (where most of any type of acid neutralization will occur). 2-Cryoboralls which have a thicker A-horizon, but which do not "attenuate protons effectively" (neutralize acids in the common vernacular).

Jeff Orth, Rocky Mountain Research - the research group has decided to expand from artificial organ research (ears, kidneys, etc.) to include acid deposition monitoring. Equipment is now being developed which will be small enough (trumpet case size) to be portable, complex enough to do high resolution analysis on a number of chemical species and inexpensive enough to be practically used by agencies and groups presently involved in water quality monitoring. The sample or sonde will cost around \$4,000, comparable to other sondes presently in use which do not make use of such a broad spectrum of chemical analyses. The method of analysis is ion chromatography. A prototype now in testing is performing quite



well with selected chemical species. The capability is being expanded to include analysis of fluoride, chloride, phosphate, nitrate sulfate, ammonium, sodium, potassium, calcium and magnesium. These parameters have traditionally been analyzed through conventional bench chemistry methods which are expensive and labor intensive. Additionally, the unit now being designed will run up to 40 samples on a single battery charge. Capability will be given to the unit to read the stored results onto a disk or to transmit data to a central computer from the site. We wish Jeff luck on this tremendous technical advance! Cliff Benoit, U.S. Forest Service - The U.S. Forest Service (U.S.F.S.) carried out the pilot program of surface water sampling in the Uintas in 1984. This project was designed to gather indicator data from key areas thought to be sensitive to acidification prior to the 1985 Western Lake Survey (WLS). Twenty lakes were surveyed in 1984 and found to be sensitive to acidification. A video tape was shown of some of the sampling areas and the procedures used during the WLS. Since many of the Uinta lakes were located within the wilderness area, helicopters were not allowed to do the sampling. The use of helicopters was standard in the Eastern Lake Survey and for the WLS non-wilderness lakes. The wilderness lakes were sampled by teams on foot or on horse back. Mr. Benoit indicated that the time frame for sampling required by EPA (project directors) put the sampling teams into the mountains during early snowfall, when many of the lakes were already beginning to freeze over. Without any serious casualties, however, the WLS was successfully completed.

The pre-print data of the WLS results are available. I previously sent a copy of my state-by-state summary to each of you.

The ADTAC efforts have lent some assistance to Air Quality Related Values (AQRV) studies being proposed by U.S.F.S. in the Uinta and Wasatch Mountains. Studies for the AQRV will include visibility and acid deposition work. Acid deposition monitoring in the Uinta Mountains is tentatively planned for the Chepeta Lake area and Brinton Meadow, near Granddaddy Lake. The State and ADTAC will seek a cooperative effort in the AQRV with U.S.F.S.

Discussion of the Acid Deposition Action Plan was also held. Unfortunately, I did not get clearance of the latest draft to get copies for ADTAC. I did have overhead slides made and these were reviewed before committee. The plan has since been redrafted (5-7-87) to exclude soil sampling by untrained crews. The revised draft should be included with this meeting review. Please note the sign-off page on page 13. This is to commit the involved agencies to carry out their assignments as described in the action plan. If changes need to be made either in assignments or in the authorized signatures, please get back with me.

I appreciate the willingness each of you has shown in participating in ADTAC and in the action plan. I enjoy working with you, keep in touch.

NOVEMBER 23, 1987

ACID DEPOSITION IN UTAH  
BY: LOGAN JUBECK

FIELD NOTES: PITTSBURG LAKE

For my Eagle project I collected water samples from Pittsburg Lake to be tested for acid rain.

Pittsburg Lake is a small but beautiful lake. It is located in the Wasatch Mountains above Mineral Basin of the American Fork Canyon.

The trail to Pittsburg Lake is very rocky and steep. There are a lot of remnants of the past, such as mining cables, mining railroad ties and tracks.

There are a lot of rocks around the lake, however the lake was very low so there was a sandy beach to perform our water sample test on.

The lake is surrounded by several large pine trees, as well as narrow leaf cottonwood. There are a lot of wild raspberries growing all around the lake, which was a real treat after the steep hike.

We observed a lot of wildlife in the area. The lake itself seemed to have a large abundance of small fish jumping in the early evening. We also saw several deer and lots of birds as we hiked to the lake.

Lake Pittsburg is an area that would be an interesting family hike, not necessarily easy, but enjoyable.

Field notes and procedures:

We collected two samples from Pittsburg Lake. One on the 25th of August and again on October 7th.

Our samples were collected as close to the outlet as possible. We used three sampling bottles. Two of the bottles were filled by submerging them in water to keep from being contaminated by material floating on the surface of the lake. The smallest bottle was then filled from the largest bottle. The following chemical test were performed on the water samples.

1. pH of the water.
2. Alkalinity of the water.
3. Hardness of the water.
4. Oxygen of the water.

Other data taken included:

1. Water temperature.
2. Air temperature.

Data Results:

August 25, 1987      Time: 1833

pH: 7.1  
Alkalinity: 7.0 mg/l low range  
Hardness: 34.0 mg/l  
Oxygen: 8.6 mg/l

Water temperature: 57 deg. F  
Air temperature: 49 deg. F

October 7, 1987

Time: 1900

pH: 7.1  
Alkalinity: 34.2 mg/l low range  
Hardness: 85.5 mg/l  
Oxygen: 4.8 mg/l

Water temperature: 54 deg. F  
Air temperature: 48 deg. F

Data changes from August to October:

pH: no change  
Alkalinity: 27.2 higher  
Hardness: 51.5 higher  
Oxygen: 4.2 lower

Water temperature: 3 deg. F lower  
Air temperature: 1 deg. F lower



NOVEMBER 23, 1987

ACID DEPOSITION IN UTAH  
BY: LAMONT JUBECK

FIELD NOTES: LAKE HARDY

For my Eagle project I collected water samples from Lake Hardy to be tested for acid rain.

Lake Hardy is located in the wilderness area of the Wasatch Mountains above the City of Alpine, Utah.

The trail to Lake Hardy is about five miles long with a steady upward climb. It took about four hours to make the climb to the lake.

Lake Hardy is found at the bottom of a rocky cirque. Most of the rock in this area is granite. The lake is beautiful, with the natural rocky amphitheater rising from the lake high into the sky.

The lake has a lot of willows and grass with several large spruce and white fir trees protecting it from intruders. It is a peaceful setting for those who dare to endure the climb.

We observed wildlife all along the trail and around the lake, such as birds, squirrels, insects, and deer. While we were taking our water samples a deer walked out into the lake for several hundred feet and jumped into a patch of willows. From this observation we noted that the lake is very shallow, thus answering our question about why there are no fish in the lake. They would be killed by the freezing of the shallow lake.

Field notes and procedures:

We collected two samples from Lake Hardy. One on the 29th of August and again on October 9th.

Our samples were collected as close to the outlet as possible. We used three sampling bottles. Two of the bottles were filled by submerging them in water to keep from being contaminated by material floating on the surface of the lake. The smallest bottle was then filled from the largest bottle. The following chemical test were performed on the water samples.

1. pH of water.
2. Alkalinity of the water
3. Hardness of the water
4. Oxygen of the water

Other data taken included:

1. Water temperature.
2. Air temperature.

Data Results:

August 29, 1987      Time: 0930

pH:                7.3  
Alkalinity:      14.0 mg/l low range  
Hardness:        17.0 mg/l  
Oxygen:          8.4 mg/l

Water temperature: 57 deg. F  
Air temperature:    58 deg. F

October 9, 1987      Time: 1217

pH:                    6.7  
Alkalinity:    102.6 mg/l low range  
Hardness:      68.4 mg/l  
Oxygen:        5.2 mg/l

Water temperature: 58 deg. F  
Air temperature:    50 deg. F

Data changes from August to October:

pH:                    .6 lower  
Alkalinity:    88.6 higher  
Hardness:      47.4 higher  
Oxygen:        3.2 lower

Water temperature: 1 deg. F higher  
Air temperature:    8 deg. F lower

**EAGLE PROJECT REPORT**  
**REID H. ELLIS**  
**September 30, 1987**

My Eagle Project consisted of taking water samples and doing field tests of the water in the George Creek water source, as a part of the statewide testing program being conducted by the Division of Environmental Health, Bureau of Air Quality. In that program, samples and testing have been done all along the Wasatch Front, but the State did not have funding to obtain the data needed from more remote parts of the State. My assigned area was a small creek on the north drainage of the Sawtooth Mountains, about 75 miles northwest of Snowville, Utah. This is a dry, dusty, and very remote area, with no hard surfaced roads. We traveled a total of 425 miles, more than a third of it on dirt roads.

In preparation for my project, I made contact with my older brother, Mark Ellis, who is in charge of the State Acid Rain Project, and asked if I could give some help on that project for my Eagle Project. I wrote him a letter, a copy of which is attached, he wrote back, approving my project and referring me to the various people I would need to contact. He also took me out to a farm pond and taught me how to use a Hach water testing kit.

I contacted Lynn Hutchison (Dr.) of Kennecott Lab, and Maureen Wilson of Utah State Wildlife Resources. Maureen gave me my place assignment. Since I had never heard of George Creek, I had to have my Dad and my brother help me locate it. It is about 15 miles south of the Utah-Idaho border in Box Elder County, Utah, the nearest town is Yost, Utah. Dr. Hutchison agreed to test the samples we collected and sent in, as part of the testing agreement, which Kennecott Lab has with the Utah Acid Rain project.

My father agreed to take myself and 6 other scouts to the site in our van, and because it is a 4 hour drive each way, we left on Friday night, driving up to my Uncle Lee Ellis farm in Fielding, where we stayed overnight. On Saturday morning we got an early start, stopped to eat breakfast in Tremonton, then drove out Freeway 84, taking the Park Valley exit. Park Valley is on the south side of the Sawtooth range, so we had to circle Sawtooth National Park, about 50 miles of dirt roads to get to Yost. Yost is a town with about 20 homes, no stores or service stations. George Creek is up a steep and rocky mountain road about 10 miles. We had a flat tire before we started up the mountain, and another just as we got to George Creek.

The main creek bed of George Creek was dry, but we located a small tributary stream which is on the same drainage, which is fed by two small springs. It was there that we filled three sample bottles to be delivered to the Kennecott Lab, and spread out our kit to do the on site testing. We did a free activity test, high and low range; total acidity test, high and low range; pH test; oxygen content, and several others. In each test we obtained a given sample of pure water, added the chemicals from the Hach kit and observed the changes of color, consistency and chemical reaction taking place. As I performed each test, my dad acted as scribe, recording the amounts of chemicals used, the changes noted, and color reaction obtained. The figures were later put into the official report form provided to me by the State.

The field tests took about 2 hours and 20 minutes; we had to repeat some of them because on the first test we had used a glass test tube to measure out the sample water and we were supposed to use a smaller plastic test tube. Our first results were too high, but when we discovered our mistake, the numbers made more sense, and we knew our test was right. The special plastic bottles provided by the lab had some acid already in them, so we had to exercise special care in taking samples, so that no one got burned. We labeled the samples; put them in a plastic bag, to protect them, and left the test site. We took photo's of the testing process, the test site, and the mountains around George Creek, to aid in identifying the site and it's closeness to the creek.

On our way out of George Creek, with no spare tire, and two flats, we had to go about five miles on a bare rim, which was slow and uncomfortable going. Once back on the main road, we got a man going the other direction who had some Stop Leak and a tire pump, with which we got our spare re-inflated, and limped 40 miles into Snowville, where we got a new tire.

It was an exiting outing, and a great project. The test samples have been delivered to my brother, who took them to Kennecott Lab, and we trust the tests will help the Acid Rain Project.